A CHARACTERIZATION OF THE CLIMATE OF THE CALIFORNIA DESERT

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for the

Desert Planning Staff, Bureau of Land Management
United States Department of the Interior, Riverside, California
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PREFACE

The following report on the climate of the California Desert Conservation Area (CDCA) is different from academically oriented and lengthy narrative reports. Most persons involved with planning and land management decisions within the Bureau of Land Management (BLM) are less concerned with theoretical considerations than with useable information and data. The report relies primarily on tabular and visual presentations, and it is hoped the format will allow rapid assimilation of climatic information by BLM personnel. In addition, and possibly of greater importance, it is hoped that the format will result in greater use of the data presented.

Several items of interest in the CDCA were not able to be evaluated to the degree planned. Weather during the winter of 1978 did not allow for the amount of field work originally planned. Data on low lying temperature inversions were obtainable only after winter conditions in the desert had effectively ended. These shallow temperature inversions develop best during the coldest months of the year. Detailed climatic sub-types were not possible to define because of the paucity of meteorological data. However, the method of data and information presentation should allow the planner or resource manager to reasonably well extrapolate climatic information from the report.

Dr. Leonard W. Bowden served as the Principal Investigator for this particular project. Dr. James R. Huning performed most analytical procedures, data presentations, and narrative preparation. David A. Nichols expended much time and effort in generating the generalized map of surface temperature conditions for the CDCA. The map was produced from analysis of satellite digital tape data with the cooperation of David McGinnis of the National Oceanographic and Atmospheric Administration. Dr. Ross Cochrane provided

the vegetation transect and conceptual relationships dealing with plant-climate factors for a test location in the environs of Death Valley and Panamint Valley. Scott Place undertook the task of examining circulation characteristics for summer in the CDCA. He used daily facsimile weather maps in conjunction with weather satellite imagery. Robert Hicks completed all photographic work and Donald Chambers drafted the bulk of the cartographic information.

Special thanks go to the following individuals for their kind assistance. Richard Wells of the Department of Water and Power, City of Los Angeles, allowed free access to the Department's weather data files; Raymond Kelso of NWC China Lake graciously provided data and information of the Indian Wells Valley and environs. James D. Goodridge, Climatologist with the Department of Water Resources, State of California, and Arndt Lorenzen of the Air Resources Board, State of California, provided much needed climatic data. A final note of thanks must go to the numerous individuals and agency representatives who responded to a generalized form letter requesting climatic data and/or impressions of the desert climate.

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CALIFORNIA DESERT CONSERVATION AREA (CDCA)

The California Desert Conservation Area (CDCA) covers nearly 25 million acres (10 million ha). The CDCA includes the Mojave Desert and parts of the Colorado Desert and Basin and Range physiographic provinces. Within these broad provinces are numerous locally identified topographic units: Owens Valley, Death Valley, Panamint Range and Valley, Antelope Valley, Indian Wells Valley, Coachella Valley, Imperial Valley; Kingston Range, Turtle Mts., Whipple Mts., Chemehuevi Mts., White Mts., and the Inyo Mts., to name a few. (Figure 1)

The large and diverse area in the CDCA includes an elevation range from lower than sea level, Badwater (-282 feet, -86m), the lowest spot in the Western Hemisphere, to more than 11,000 feet (3,353m) in several of the desert mountain ranges. Naturally such a large and diverse area includes a variety of climatic niches and several distinct climatic types. Temperature and precipitation variability describe most of the characteristics of the desert climate.

The general terms High Desert and Low Desert are, more or less, according to elevation, which in turn serves as a major control upon both temperature and precipitation. Precipitation in the CDCA, by definition, is scant. The amount of precipitation a place receives is extremely variable and determined, in part, by elevation, slope and exposure. Several of these factors will be addressed in the following pages.

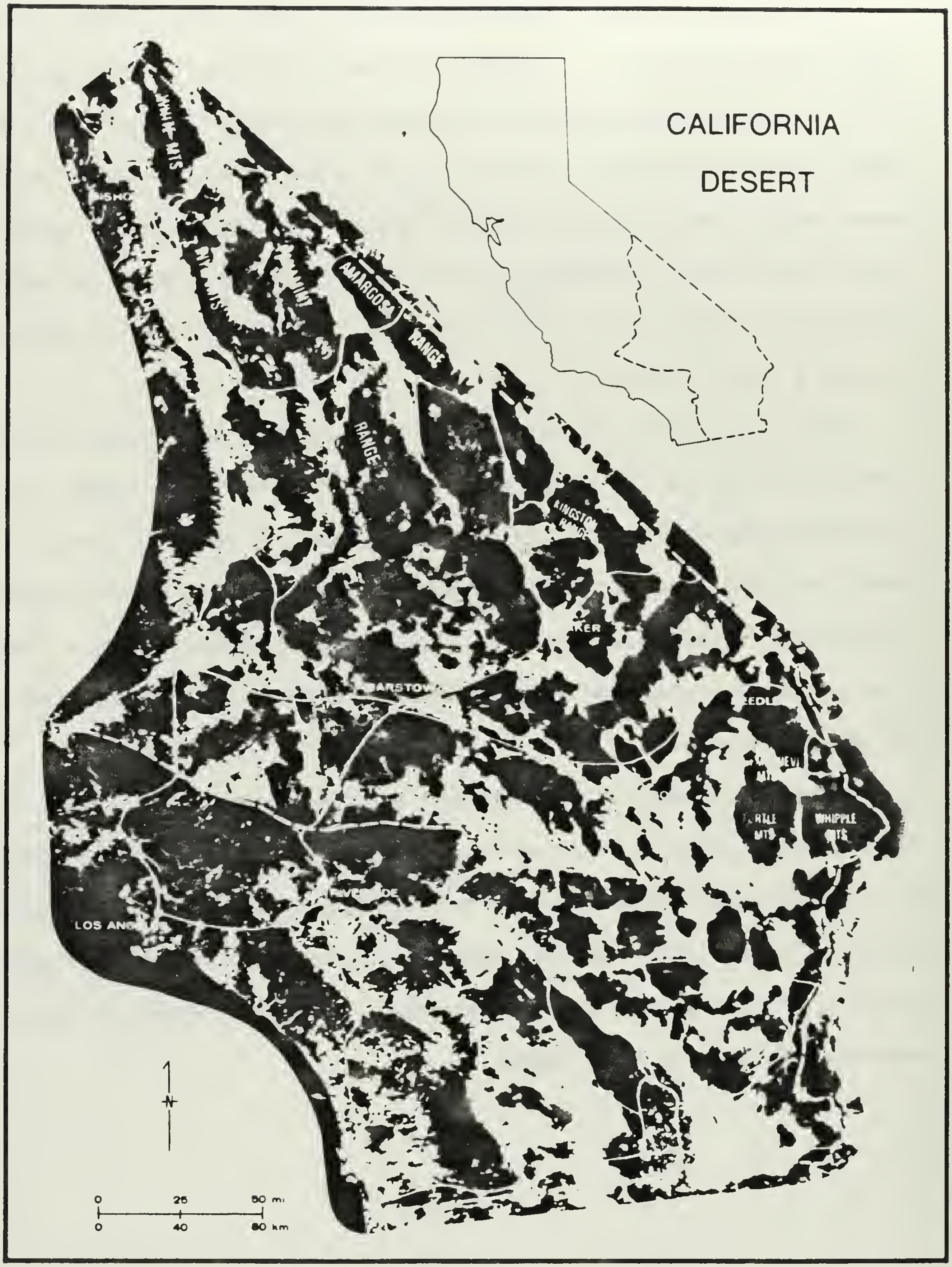

CALIFORNIA
DESERT
AMARGOSA
RANGE
RANGE
BARSTOW
WHIPPLE
LOS ANGELES
0
25
50 mi
0
40
80 km
N

Fig 1

Global Parameters

The CDCA's latitudinal and continental positions are under the direct influence of the semi-permanent sub-tropical high pressure cell located in the eastern Pacific Ocean. Air moving out of this cell (diverging) causes a southwesterly to westerly wind flow over the CDCA much of the year. Air diverging from this cell is characteristically warm and dry as a result of settling (subsidence) from higher altitudes. The air passes over a cold off-shore ocean (California Current) so little evaporation is added to the air and thus the air stream that moves on-shore is dry and stable. Because the CDCA is located to the lee (downwind) side of numerous mountain chains (Sierra Nevada, San Bernardino, San Gabriel, San Jacinto, Santa Rosa), the area is a "rainshadow" desert. Thus, the factors of atmospheric circulation, ocean temperatures and physical isolation from moisture sources form the basic climatic patterns of the CDCA. However, because of elevation differences found in the area and the rather large latitudinal extent of the CDCA, internal climatic differences are present and important to the resource manager or planner.

INTRODUCTION - SEASONAL OVERVIEWS

Normal weather patterns of the CDCA are influenced by global circulation patterns. Foremost among these patterns is the seasonal migration of the Pacific High pressure cell; a semi-permanent feature of the atmosphere located above the Pacific Ocean. The latitudinal position and intensity of the Pacific High are closely correlated to the seasons, and the High migrates north and south with the sun.

The Pacific High migrates to its most northerly position and maximum intensity during summer. The high pressure cell serves as a barrier to cooler and wetter cyclonic storms that sweep across the North American continent from the North Pacific. The cell effectively blocks most storms from moving onto the coast of central and southern California, and, for that matter, much of the western United States. Characteristically, the summer weather in coastal and central California is dry and warm (commonly termed a Mediterranean type climate). Periodically a summer storm may penetrate into California, but more commonly a small atmospheric disturbance, (e.g., an upper level low) will pass over California. Associated with the upper level low are cooler air temperatures and unstable atmospheric conditions. Because of its ambient temperature, an upper level low often brings gusty winds and unstable weather to the California Desert. For the most part, an upper level low has a relatively minor effect on the CDCA.

Summer circulation over the CDCA is dominated by anticyclonic circulation (high pressure); anticyclonic circulation characteristically brings clear skys and warm temperatures as a result of increased input of solar radiation and air subsidence. Air subsidence of anticyclonic circulation dominates much of the CDCA. Even so, a thermal trough may often be found at 5,000 - 10,000 feet (1524 - 3048m) above the CDCA during summer, and if

the trough is oriented northeast-southwest, an influx of warm, wet maritime tropical air may result. The immediate effect of an influx of unstable maritime air is the frequent occurrence of thunderstorm activity and the likelihood of flash flooding during late afternoon and evening hours.

As will be noted later, the influx of tropical air affects the eastern and southern portions of the CDCA more than the westerly locations. Especially important to the CDCA in late summer and early fall is the formation of tropical storms off the coast of Mexico. When this occurs, intense thunderstorm activity often results in the desert. Periodically the tropical storm may move on-shore and into the southern portions of the CDCA, such as occurred in 1976 and 1977.

After the autumnal equinox, winter circulation patterns become established. Direct rays of the sun now strike in the southern hemisphere and all global pressure and wind systems migrate south. The Pacific High not only migrates south, but its intensity also diminishes. As the cell weakens, more cyclonic storms are allowed to move onto the coast of California. These cyclonic disturbances bring the bulk of precipitation to stations located in the CDCA and throughout California.

By definition, however, all locations in the CDCA are dry, and there is never a surplus of long-term moisture available (i.e. potential evaporation exceeds precipitation). Possibly surprising to most persons is that throughout winter, too, anticyclonic circulation predominates. The circulation pattern is disrupted only by the passage of a cyclonic storm, or front. Frontal disturbances are most effective in the western and northern portions of the CDCA; becoming less intense and effective in the eastern and southern margins of the CDCA. Often no precipitation falls from these disturbances

because of the CDCA's location in the rainshadow (leeward) side of the Sierra Nevada and other mountain ranges. Cloudy skies, predominately stratus clouds, and gusty winds often accompany the passage of a storm.

Spring and autumn represent two transitional seasons. Of the two, spring is the most important, for the windiest months occur during spring in the CDCA.

The following pages present thermal and moisture particulars of the CDCA, and give an overview of wind conditions for the area.

ADVECTIVE AND SOLAR CLIMATE

In all desert environments there is a distinction that must be made between solar climate and advective climate. Although the two are important in all climatic environments, they are most recognizable in a desert (including polar deserts). Simply, the difference between the two climatic types is a function of how strong surface winds blow. Lack of substantial vegetative cover results in air movement near the ground surface. If air movement is minimal, then the solar climate dominates. That is, temperature characteristics, especially the sensible temperature felt by the human body, result from radiational parameters. Direct solar input leads to increased surface heating and convective motion. Hot air temperatures often result. The advective climate comes into play when strong air movement causes mixing of the hot surface layer and/or brings air masses from other geographical areas. Most likely, every visitor to the CDCA has experienced, at one time or another, the change from a solar climate to an 'advective one', but perhaps the letter from Robert Ausmus, proprietor of the Cima Store, Cima, CA, best describes the phenomenon (see entire letter in Appendix):

> Speaking from personal observations, I would say that our weather in the high elevations (4000 to 7000 feet) near Cima is generally unpredictable. We seem to be in an area where erratic weather conditions can be brought about by coastal (or Baja) storms and also by storms coming out of Nevada, Utah, and Colorado. Sudden strong northern winds can lower temperatures radically in just a few hours. I have seen the temperature drop from 50°F to 15°F in little more than three hours when cold air from Utah or northern Nevada suddenly moves in on us.

Mr. Ausmus is obviously describing the change from the solar climate to an advective one. The speed at which the change can take place is a function of macro- and meso-scale circulation factors.

Mr. Ausmus provided other personal recollections that are incorporated elsewhere in this characterization of the CDCA's climate.

To the lee of the Sierra Nevada, one can often experience a rapid change in weather brought about by extreme advective processes. Whenever a Sierra Wave (westerly wind over the Sierra crest that descends rapidly with high wind velocities) develops leeward of the Sierra Nevada, the Owens Valley, Indian Wells Valley and south along the southern flank of the Sierra Nevada experience high velocity winds and a rapid change in temperature. James Huning has seen the temperature drop from nearly 90°F (32°C) to below freezing in less than 8 hours. Wind in excess of 70 mph (113 kph) was also recorded in open areas along the eastern slope of the Sierra Nevada. Protection from the weather elements is necessary in all seasons in the CDCA. The best weather advice to a visitor to the desert is to "expect the unexpecte

TEMPERATURE CHARACTERISTICS

Table 1, in addition to presenting analyzed data useful for planning purposes, contains several pertinent factors. Of greatest interest is the number of days per year that have a mean daily temperature below 43.6°F (6.4°C). This value can be used to approximate the relative importance of shallow temperature inversions in the desert. An examination of the table shows that most stations with a large number of such days are located in or near valley bottoms (Naval Weapons Center (NWC) China Lake, Lucerne Valley, Lancaster) or are strongly influenced by air drainage from surrounding highlands. (e.g., Bishop) Of course, stations that have elevations near sea level (Death Valley, most stations in the Low Desert: Coachella and Imperial Valleys) do not record many cold days.

Note the data for NWC China Lake and Randsburg. According to the calculations, NWC China Lake, located in a valley bottom, has 34 days per year that the mean daily temperature drops below 43.6°F (6.4°C). Randsburg, geographically near NWC China Lake but at a considerably higher elevation and above areas affected by air drainage, calculates zero days per year with mean daily temperature below 43.6°F (6.4°C). Inyokern, only slightly higher than NWC China Lake, also has zero days per year with mean daily temperature below 43.6°F (6.4°C). A partial explanation is that Inyokern is also open to more air movement from the Sierra Nevada just to the west and to air flow through in Owens Valley, a major wind corridor. NWC China Lake is in a more protected location and thus temperature inversions are more likely to develop and persist.

Similar conditions account for the large number of days per year with a mean daily temperature below 43.6°F (6.4°C) at Lucerne Valley. Here, isolation from meso-scale air movement, and a valley bottom location that

TABLE 1

NUMBER DAYS PER YEAR HAVING THE FOLLOWING MEAN DAILY TEMPERATURES (°F)

	<43.6	>50.0	>60.0	>70.0	>86.0	<100	Daily Means: Min. Temp	Daily Means: Max. Temp
BARSTOW	0	287	206	142	0	365	45.4	85.7
BISHOP	97	218	156	81	0	365	52.4	92.6
DAGGETT AP	0	306	217	158	39	365	47.5	87.8
DEATH VALLEY	0	365	271	217	131	329	51.5	101.9
DEEP SPRINGS	129	198	136	72	0	365	30.3	75.0
FAIRMONT	13	251	170	104	0	365	43.8	79.8
HAIWEE	69	241	179	113	0	365	39.6	81.4
INYOKERN	0	274	199	139	0	365	44.4	84.8
LANCASTER	30	252	185	118	0	365	42.8	83.3
LUCERNE VALLEY	42	247	180	115	0	365	42.7	81.9
NEEDLES	0	365	250	193	106	365	51.6	95.3
NWC CHINA LAKE	34	275			21	365		
PALMDALE	0	267	185	115	0	365	44.4	82.1
PARKER	0	365	255	191	91	365	51.3	93.8
RANDSBURG	0	267	194	132	0	365	44.3	84.3
SQUIRREL INN	104	189	113	0	0	365	38.7	69.7
TABLE MTN	156	161	98	0	0	365	33.0	68.2
TRONA	0	288	219	164	53	365	44.6	89.8
TWENTYNINE PALMS	0	331	227	168	58	365	49.0	89.3
VICTORVILLE	23	246	176	110	0	365	43.2	79.8
WHITE MTN 2	321	0	0	0	0	365	14.8	45.8

(Continued)

	<43.6	>50.0	>60.0	>70.0	>86.0	<100	Daily Means: Min. Temp	Daily Means: Max. Temp
BLYTHE	0	365	260	193	87	365	52.4	92.6
BRAWLEY	0	365	272	200	97	365	53.8	93.5
EL CENTRO	0	365	268	196	91	365	53.4	92.7
IMPERIAL	0	365	271	196	89	365	54.0	92.2
INDIO DATE GARDEN	0	365	274	203	93	365	53.9	92.3
IRON MTN	0	365	264	201	109	365	53.0	95.2
MECCA	0	365	269	196	84	365	53.7	90.9
PALM SPRINGS	0	365	266	191	71	365	53.8	91.0
THERMAL	0	365	270	200	97	365	54.3	92.8
ARIZONA AND NEVADA STATIONS								
ADAVEN	157	169	106	20	0	365	28.9	70.6
BOULDER CITY, NV	0	290	219	165	55	365	45.6	89.2
BOUSE	0	331	233	175	76	365	48.8	92.6
CALIENTE	127	199	140	73	0	365	30.3	76.5
EHRENBERG	0	365	262	194	90	365	52.2	93.0
KINGMAN	20	255	188	123	0	365	43.2	82.6
KOFA MTN	0	365	280	198	89	365	55.2	91.5
LAS VEGAS AP, NV	18	274	212	160	62	365	43.3	90.4
MINA	129	197	140	79	0	365	32.0	78.8
QUARTZSITE	0	343	257	190	94	365	49.3	95.3
YUMA AP	0	365	292	209	108	365	56.3	95.2
YUMA CITRUS	0	365	264	190	84	365	53.2	92.2

allows for accumulation of cold air and development of a temperature inversion, gives Lucerne Valley its high value (42 days per year). Of particular interest in the case of Lucerne Valley is that according to published Weather Bureau data, Lucerne Valley registers the greatest number of days per year that the temperature drops below freezing, 104 days, of all stations for which data are available. Thus, it is reasonable to assume that data presented in column 1 of Table 1 allow for a reasonable determination of the frequency of temperature inversions, more anon.

Table 1 also presents data on number of days with mean temperatures that are considered critical either for biological considerations or recreation. Of particular interest here are columns 2 and 5, number of days with mean temperature above 50°F (10°C) and greater than 86.0°F (30°C), respectively. The critical temperature of 50°F (10°C) is considered a reasonable temperature for recreational purposes. Although the temperature at night may drop to, or near, freezing, the day time temperature would be warm. The assumption being made is that most persons would be staying in a tent or, in most cases, a recreational vehicle. Thus, the cool to cold night time temperatures should not present a significant constraint to a visitor. In conjunction with column 4, number of days per year with the mean daily temperature above 70°F (21.1°C), an evaluation of the actual number of days per year that would indicate recreational usage is determined. The assumption here is made that if the mean daily temperature consistently exceeds 70°F (21.1°C), then the day time temperature might be too high for most individuals. Data giving the number of days when the mean daily temperature exceeds 86.0°F (30°C) are presented, because that is a critical temperature for plant growth. (Ross Cochrane, personal communication). Note that Death Valley is the only station that calculates mean daily temperatures in excess of 100°F

(37.8°C), with a total of 36 days above 100°F (37.8°C).

Data are given for White Mountain 2, a research station located in the White Mountains, east of Owens Valley, to serve as an example of an alpine desert station. Cold and dry conditions characterize the environments of many high elevation desert ranges. Note, particularly, the extreme cold conditions at White Mountain 2. At White Mountain 2 all but 44 days of the year have mean daily temperatures less than 43.6°F (6.3°C). By comparing these data with data from Table 2, which gives calculated data on the percent of annual hours below freezing, one can see that high elevation mountain areas in the desert have extreme climatic conditions, especially for a mid-latitude location. At White Mountain 2, more than 63 percent of the annual hours fall below freezing.

TABLE 2

YEAR BEG	YEAR END	I.O. NO.	STATION NAME	WATER NEED	WARMTH	DAYS > WARMTH	TEMPER-ATENESS	PER CENT OF ANNUAL HOURS < FREEZING	MEAN ANNUAL TEMPERATURE RANGE 'A'	MEAN ANNUAL TEMPERATURE
0	0	9	BARSTOW	5.17	59.18	215.01	48.16	2.787	39.40	64.60
0	0	10	DAGGETT AP	5.45	59.73	224.33	46.76	2.152	39.70	66.70
0	0	11	DEEP SPRINGS	3.94	56.12	165.18	47.02	13.564	44.50	52.80
0	0	12	INYOKERN	5.06	58.90	210.27	48.45	3.327	39.90	63.60
0	0	14	LANCASTER	4.74	58.26	199.75	50.12	4.148	38.70	61.10
0	0	51	NWC CHINA LAKE	5.16	58.90	210.32	46.70	4.127	43.20	64.00
0	0	15	LUCERNE VALLEY	4.68	58.12	197.51	50.23	4.454	36.30	60.60
0	0	16	RANDSBURG	4.98	58.74	207.73	48.83	3.534	39.70	63.00
0	0	20	TWENTYNINE PALMS	5.67	60.15	231.67	45.65	1.734	39.60	68.30
0	0	21	VICTORVILLE PUMP PLANT	4.59	58.03	195.99	51.90	3.796	36.10	60.10
0	0	22	BISHOP AP	4.19	56.88	177.39	50.51	7.816	39.10	56.00
0	0	25	DEATH VALLEY	7.15	61.52	257.42	37.20	1.629	49.60	76.40
0	0	27	HAIWEE	4.62	57.85	193.06	49.11	5.917	41.30	59.70
0	0	31	PALMDALE	4.77	58.43	202.61	50.86	3.352	37.00	61.60
0	0	35	TRONA	5.52	59.51	220.51	44.91	3.310	44.30	66.60
0	0	39	LAS VEGAS AP	5.50	59.30	217.03	44.24	4.154	46.60	66.10
0	0	40	BOULDER CITY	5.54	59.62	222.40	45.10	2.964	43.40	66.90

********** STATISTICAL SUMMARY **********
********** NO. OF OBS = 17 **********

	MEAN	VARIANCE	STANDARD DEVIATION	COEFFICIENT OF VARIATION
RELATIVE WATER NEED	5.10	0.52	0.72	4.24
WARMTH	58.78	1.57	1.25	7.37
DAYS WITH TEMPERATURE > WARMTH	208.72	444.45	21.08	124.01
TEMPERATENESS	47.40	12.10	3.48	20.47
PER CENT OF ANNUAL HOURS < FREEZING	4.28	7.94	2.82	16.57
MEAN ANNUAL RANGE OF TEMPERATURE	41.24	12.54	3.54	20.83
MEAN ANNUAL TEMPERATURE	63.42	27.75	5.27	30.99

YEAR BEG	YEAR END	I.D. NO.	STATION NAME	WATER NEED	WARMTH	DAYS > WARMTH	TEMPER-ATENESS	PER CENT OF ANNUAL HOURS < FREEZING	MEAN ANNUAL TEMPERATURE RANGE 'A'	MEAN ANNUAL TEMPERATURE
0	0	38	YUMA AP	6.66	62.05	268.63	41.07	0.496	38.40	75.00
0	0	37	YUMA CITRUS STATION	6.17	61.22	251.41	43.52	0.824	38.30	71.90
0	0	36	PARKER	6.22	60.93	246.00	42.44	1.333	41.90	71.80
0	0	32	PALM SPRINGS	6.08	61.23	251.67	44.36	0.693	36.70	71.50
0	0	30	INDIO DATE GARDEN	6.35	61.57	258.42	42.67	0.645	38.00	73.10
0	0	29	IMPERIAL	6.26	61.46	256.14	43.16	0.670	37.70	72.60
0	0	26	EL CENTRO 2 SSW	6.28	61.38	254.70	42.88	0.767	38.60	72.60
0	0	24	BRAWLEY 2 SW	6.38	61.51	257.31	42.29	0.737	39.00	73.20
0	0	23	BLYTHE	6.19	61.13	249.68	43.13	0.973	37.50	71.90
0	0	19	THERMAL AP	6.35	61.55	258.08	42.61	0.665	38.20	73.10
0	0	17	NEEDLES	6.39	61.06	248.42	41.34	1.392	43.40	72.70
0	0	16	MECCA 3 SE	6.17	61.38	254.67	43.81	0.645	36.90	72.10
0	0	13	IRON MTN	6.50	61.39	254.76	41.12	1.038	42.00	73.60

********** STATISTICAL SUMMARY **********
********** NO. OF OBS = 13 **********

	MEAN	VARIANCE	STANDARD DEVIATION	COEFFICIENT OF VARIATION
RELATIVE WATER NEED	6.31	0.02	0.16	1.20
WARMTH	61.37	0.09	0.30	2.29
DAYS WITH TEMPERATURE > WARMTH	254.61	32.40	5.69	43.78
TEMPERATENESS	42.64	1.03	1.01	7.80
PER CENT OF ANNUAL HOURS < FREEZING	0.84	0.07	0.27	2.10
MEAN ANNUAL RANGE OF TEMPERATURE	39.12	4.24	2.06	15.84
MEAN ANNUAL TEMPERATURE	72.70	0.90	0.95	7.30

YEAR BEG	YEAR END	I.D. NO.	STATION NAME	WATER NEED	WARMTH	DAYS > WARMTH	TEMPER-ATENESS	PER CENT OF ANNUAL HOURS < FREEZING	MEAN ANNUAL TEMPERATURE RANGE 'A'	MEAN ANNUAL TEMPERATURE
0	0	34	TABLE MTN	3.47	54.74	142.00	50.12	13.154	34.10	48.90
0	0	33	SQUIRREL INN2	3.77	55.75	159.04	54.75	6.554	30.30	52.70
0	0	28	FAIRMONT	4.56	57.98	195.16	52.19	3.765	35.70	59.90

********** STATISTICAL SUMMARY **********
********** NO. OF OBS = 3 **********

	MEAN	VARIANCE	STANDARD DEVIATION	COEFFICIENT OF VARIATION
RELATIVE WATER NEED	3.93	0.32	0.56	18.81
WARMTH	56.15	2.75	1.66	55.24
DAYS WITH TEMPERATURE > WARMTH	165.40	737.03	27.15	904.94
TEMPERATENESS	52.35	5.37	2.32	77.21
PER CENT OF ANNUAL HOURS < FREEZING	7.82	23.25	4.82	160.72
MEAN ANNUAL RANGE OF TEMPERATURE	33.37	7.69	2.77	92.46
MEAN ANNUAL TEMPERATURE	53.83	31.21	5.59	186.23

YEAR BEG	YEAR END	I.D. NO.	STATION NAME	WATER NEED	WARMTH	DAYS > WARMTH	TEMPER-ATENESS	PER CENT OF ANNUAL HOURS < FREEZING	MEAN ANNUAL TEMPERATURE RANGE 'A'	MEAN ANNUAL TEMPERATURE
0	0	52	WHITE MOUNTAIN 2	2.03	47.48	******	33.50	63.100	29.60	27.50

YEAR BEG	YEAR END	I.D. NO.	STATION NAME	WATER NEED	WARMTH	DAYS > WARMTH	TEMPER-ATENESS	PER CENT OF ANNUAL HOURS < FREEZING	MEAN ANNUAL TEMPERATURE RANGE 'A'	MEAN ANNUAL TEMPERATURE
0	0	1	ADAVEN	3.52	54.97	146.05	46.66	17.415	41.20	48.60
0	0	2	CALIENTE	3.98	56.22	166.67	46.58	13.726	45.60	53.10
0	0	3	MINA	4.05	56.37	169.13	46.49	13.280	46.10	53.70
0	0	4	BOUSE	5.89	60.33	234.88	43.93	1.896	42.20	69.50
0	0	5	EHRENBERG	6.25	61.23	251.61	42.80	0.926	39.60	72.30
0	0	6	KINGMAN	4.80	58.39	201.89	49.83	3.955	38.90	61.60
0	0	7	KOFA MTNS	6.26	61.80	263.27	43.83	0.380	34.70	72.90
0	0	8	QUARTZSITE	6.30	60.82	243.94	41.51	1.701	44.40	72.00

********** STATISTICAL SUMMARY **********
********** NO. OF OBS = 8 **********

	MEAN	VARIANCE	STANDARD DEVIATION	COEFFICIENT OF VARIATION
RELATIVE WATER NEED	5.13	1.38	1.18	14.69
WARMTH	58.77	6.97	2.64	33.00
DAYS WITH TEMPERATURE > WARMTH	209.68	2006.07	44.79	559.86
TEMPERATENESS	45.20	7.16	2.68	33.45
PER CENT OF ANNUAL HOURS < FREEZING	6.66	48.05	6.93	86.65
MEAN ANNUAL RANGE OF TEMPERATURE	41.59	14.79	3.85	48.07
MEAN ANNUAL TEMPERATURE	62.96	100.23	10.01	125.14

General Temperature Inversions

A normal atmospheric condition is for temperature to decrease with an increase in altitude. During times when an inversion is present, temperature will increase with an increase of altitude until the top of the inversion is reached. The altitude of the inversion ceiling will be variable, depending upon the intensity of the temperature inversion, which in turn is a function of synoptic atmospheric conditions.

In the desert, shallow or low lying temperature inversions may develop during the evening as a result of a combination of factors. Primary among these is radiational cooling of the surface. During the evening hours, the ground emits heat (in the form of longwave radiation), and in turn the ground temperature decreases. Because desert air is usually dry, outgoing radiation from the surface escapes into space. (In humid environments, water vapor and carbon dioxide in the atmosphere serve to trap outgoing longwave radiation and heat the atmosphere, which can then radiate part of the heat back toward the ground.) In the desert, most of the outgoing radiation is lost to space, and therefore not radiated back to the ground. The "greenhouse effect" of the earth-atmosphere system is not very efficient in the desert.

As the temperature of the ground decreases, the air in contact with the ground is cooled. The ground surface chills much more rapidly than the air causing the lowest lying air layers to be rapidly chilled to a temperature less than the air layers above them. Cold air is more dense than warm air and thus tends to settle (become stable). Further cooling during the night results in a progressively deeper air layer becoming chilled. Coldest air temperatures are normally recorded next to, or near, the ground, with less cold air temperatures recorded at higher altitudes. Eventually, an altitude is reached so that the cooling of the air column ceases. That

is, the top or ceiling of the temperature inversion is reached (the warmest air temperature). Above the inversion ceiling, a normal temperature lapse (decrease) of the atmosphere begins (surface temperature effects are negligible), and decreases in temperature occur until the tropopause is reached. Because the cold low lying air under the inversion ceiling is more dense than the warmer air above the inversion, no convective (vertical) air motions develop. The low lying air is very stable (it resists vertical motion).

A temperature inversion normally dissipates sometime after sunrise. Surface heating eventually initiates convective currents in the air which destroy the inverstion (air mixing occurs). During winter in some locations the reception of solar energy is reduced (because of angle of incidence and topographic location or exposure) and the temperature inversion may persist for days at a time.

Inversions develop on a seasonal basis because of the physical processes involved in their formation. The most intense temperature inversions develop during winter rather than summer. During winter, less solar insolation is received and the angle of incidence is more acute. A larger percentage of hours without sunshine per day during winter favors the development of intense temperature inversions. Consequently, the ground surface cools to a greater degree during winter than during summer, and this cooling in turn allows for a more significant chilling of a deeper air column than during summer.

If sufficient ground heating occurs and the air contains significant amounts of water vapor, the convective currents that are set up may result in the formation of cumulus clouds, especially during the summer. The base of the cloud would represent the dew point elevation of the air mass, or the elevation to which the air mass must be cooled before condensation occurs.

These convective air movements often result in gusty wind conditions during the afternoon.

Synoptic conditions most favorable for the formation of an intense temperature inversion are long night time hours so that a radiational cooling can continue for a long time, high humidity, a slight movement of air to allow for very minor air mixing and a clear sky so that outgoing radiation from the Earth escapes to higher altitudes. Strong air movement precludes the formation of a temperature inversion because too much mixing of the lower air column and the over lying air occurs and chilling cannot occur. Air drainage from nearby highlands enhances formation of an inversion in valley locations. The more dense cold air slowly drains downslope from the surrounding highlands in the early evening and settles in the lowest lying areas; the air is then further chilled by radiational cooling.

Temperature Inversions Within the CDCA

Temperature inversion development within the CDCA can be determined, at least relatively, in several ways. Data contained in Table 1 can help define temperature inversion persistence. According to data from Table 1, at Victorville, 23 days out of the year record mean daily temperatures below 43.6°F (6.4°C), yet the minimum daily mean temperature is 43.2°F (6.2°C), a difference of only 0.4°F (.2°C). The fact that there are 23 days with the stated critical temperature and only a 0.4°F (-.2°C) temperature difference between the critical temperature and the minimum daily temperature means that during the cold season, a persistent shallow inversion has developed over Victorville. That is, the temperature curve for Victorville flattens during winter when a shallow temperature inversion develops. Similar conditions exist for all low lying locations in the high desert. Compare data for Lucerne Valley and Lancaster. Inversions develop in the low desert, too, but their ambient temperature is considerably higher than stations located in the high desert. In addition, inversions in the low desert would break down sooner after sunrise than those at stations in the high desert, where an inversion may persist for days.

As previously noted, numerous areas in the CDCA are susceptible to air drainage from surrounding highlands. Air drainage, which serves to enhance temperature inversion development and persistence, commonly occurs in Lucerne Valley, Palmdale, Indian Wells Valley, Searles Valley, Panamint Valley, and Death Valley (although the low elevations of Death Valley reduce the effect of cold air accumulations). In the Salton Trough (Coachella and Imperial Valley) intense and persistent temperature inversions are not as common as in the high desert, nor is the effect of air drainage as pronounced. When an inversion does develop in the Salton Trough, it is usually very

shallow and dissipates soon after sunrise. An inversion in the Salton Trough can be identified by the relatively poor visibilities that result (due to a high moisture content from irrigation of the low lying air).

Analysis of Satellite Thermal Digital Data

One of the major problems in understanding inversions in the CDCA is the lack of conventional meteorological recording stations. The complex topography, which is intimately related to inversion dynamics, makes the lack of data even more serious. The ideal data base for inversion analysis would be a regularly and closely spaced sample of temperatures at the earth's surface and at regular altitudinal intervals up to about 3,000 feet (915 m).

The ideal data base described above is presently unobtainably (at any reasonable cost) given our present state of technology. Satellites can be used to measure temperature at the earth's surface on a regular sample basis, but cannot reliably measure ambient air temperature in a profile above the ground within the limits of inversion formation. The present section describes an attempt to use satellite acquired temperature data for gaining an understanding of inversion distributions and intensities.

There are many satellites in space which "look" at the earth. These satellites are used for telecommunications, weather forecasting, earth resources observations, intelligence gathering, and navigational purposes. The satellites designed for weather forecasting and circulation observations are operated by the National Oceanic and Atmospheric Admisistration (NOAA), National Environmental Satellite Service (NESS). Since these satellites are used for weather forecasting, they are designed to measure temperature at the earth's surface. This is done by measuring the energy emitted (long wave radiation) in the wavelength band from approximately 10.5 - 12.5 microns. The 10.5 - 12.5 micron is preferred because water vapor interference with the emitted energy is at a minimum. Images and data recorded by sensing in this spectral band are called thermal infrared (TIR).

Of the several satellites operated by NOAA and imaging in TIR, the NOAA-5 satellite was chosen for this project because of the Very High Resolution Radiometer (VHRR), a scanner that provides TIR data with approximately a 0.9 kilometer resolution. Other weather satellites have TIR resolution closer to 9 kilometers.

Weather satellite data can be ordered in either photographic form (Figure 2) or in digital form on magnetic tape. The photographic imagery has a drawback in that it is not calibrated. That is, the grey tone on an image cannot be directly correlated to a specific temperature value. To obtain actual temperature values, the digital data must be used in conjunction with NOAA-supplied calibration parameters and procedures.

For this study, a photographic image and corresponding digital data were acquired from NOAA. The scene was recorded approximately 0800 local time on 12 December 1977, shortly after passage of a storm. The data were converted to actual temperature values using the calibration procedure recommended by NOAA (Nunolt, 1977). Certain geometric distortions were removed using an algorithm described by Legeckis and Pritchard (1976). The end result was a matrix of radiation temperature values; each value representing .9 kilometers on the earth's surface. This matrix was then displayed on a film recorder resulting in a color image where each individual color corresponds to an actual temperature range (Figure 3).

It can readily be seen in either image (Figures 2 and 3) that certain basins are actually colder than the surrounding highlands, leading inevitably to the conclusion of inversion formation. It can also be seen that in the north-south oriented mountain ranges, the rising sun has warmed the east facing slopes, while the west facing slopes remain relatively cool.

Although radiation temperature as measured by a satellite does <u>not</u> necessarily precisely correlate with ambient air temperature as measured

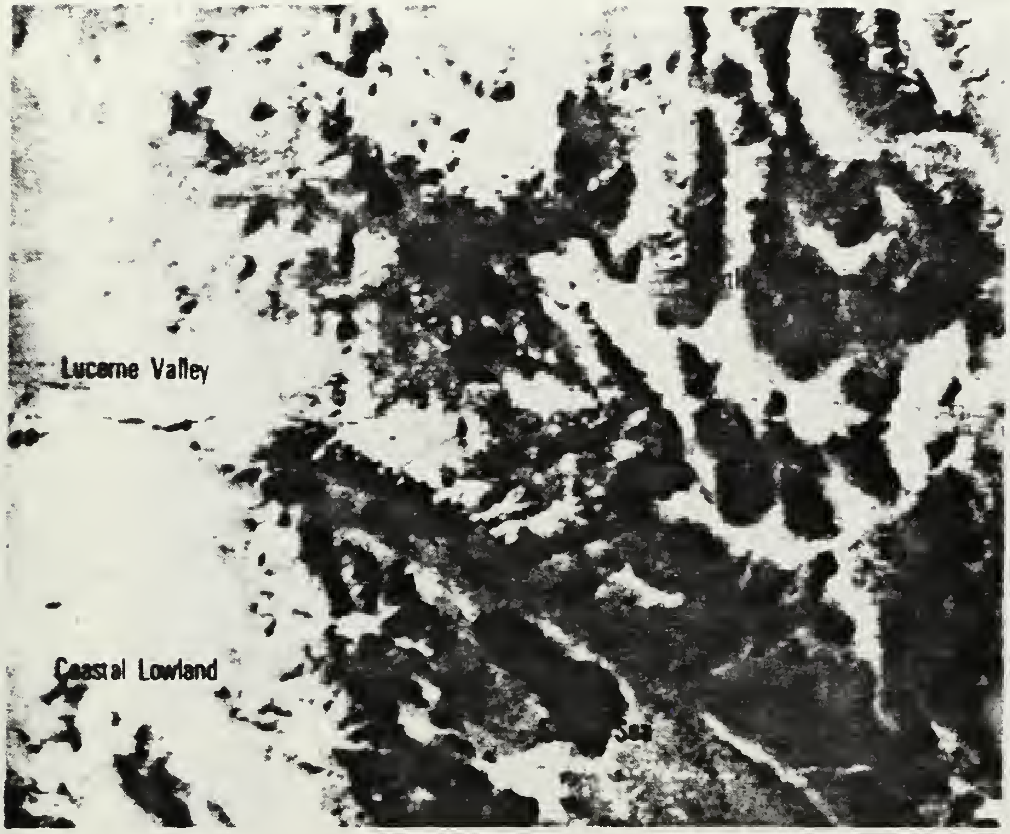
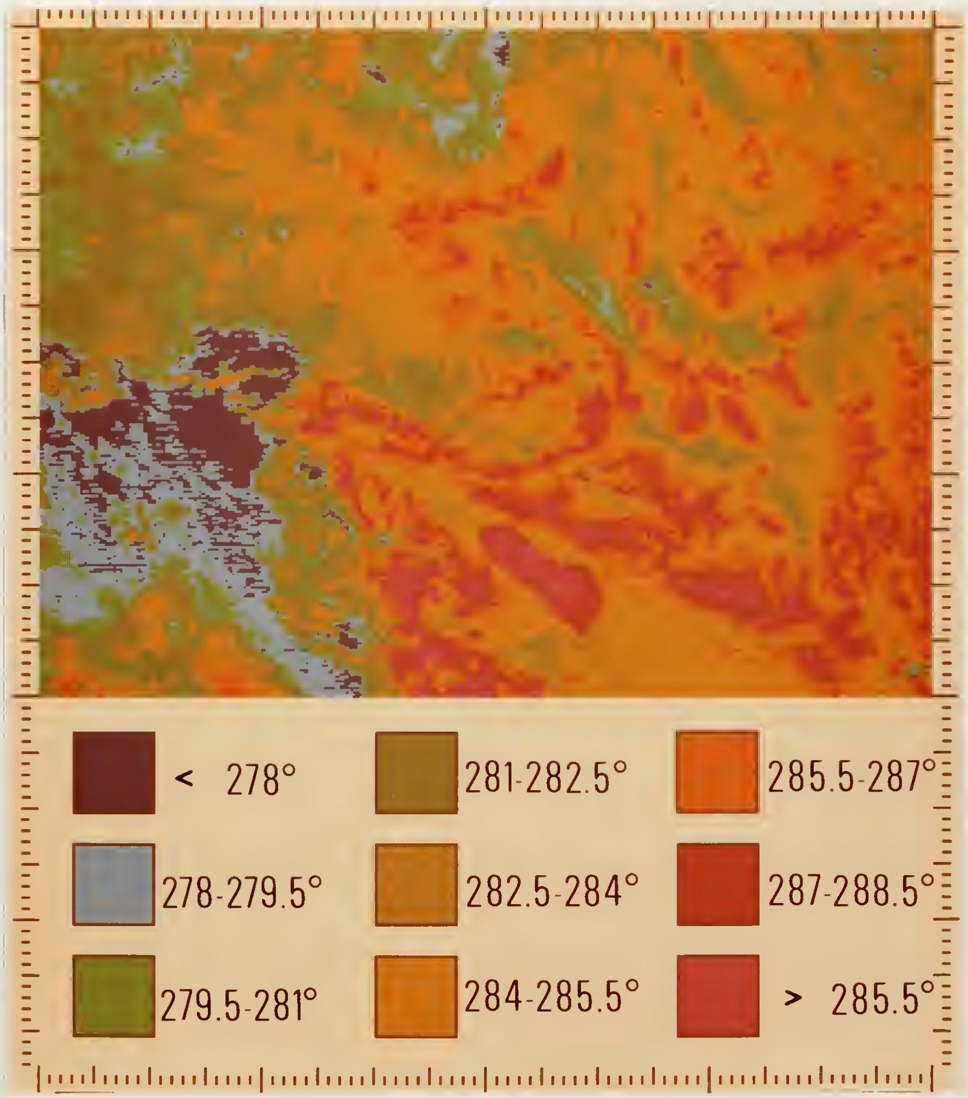


Fig 2

On this image the lighter tones represent the coolest temperatures. The image is not calibrated for actual temperature measurements.
SOURCE: NOAA-5, Thermal Infrared 10.5 - 12.5 microns, December 12, 1977

Figure 3 is a color image of the same area as represented by Figure 2. For this image the data have been used to generate actual surface temperatures via a calibration procedure. The different colors on the image correspond to a specific temperature range in degrees Kelvin.

The image was produced on a color film recorder, courtesy of the Image Processing Lab, Jet Propulsion Laboratories, Pasadena, CA.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279.5-281°
281-282.5°
282.5-284°
284-285.5°
285.5-287°
287-288.5°
> 285.5°

by a thermometer, the two are normally in close agreement. A sample of several points with known ground temperature readings were compared with the satellite derived temperatures. The variance was within a couple of degrees centigrade.

The use of satellites is the only way in which we can gain a better understanding of the distribution and extent of inversion in the CDCA. This study serves to both substantiate what is known about inversions in the CDCA and to suggest a method for further investigation. Satellite data acquired with concurrent ground sampling for better calibration of data and analyzed for several time periods would reveal much more information about inversions in the CDCA.

Actual Inversion Data

Actual inversion data for point locations are presented in Figure 4. Daily data were obtained from the state Air Resources Board and then averaged for presentation. Temperature inversion data are available for five stations in the desert; the two presented in Figure 4 are considered typical. As Figure 4 illustrates, the temperature inversions both are substantial and shallow. In fact, had data been recorded nearer to the ground than 500 feet (152m), it is likely that the inversion would have been even more pronounced than indicated. Note that the data were collected during fall and late spring for Palm Springs and Independence, respectively. Had the data been recorded during winter (January or February), the inversion depth and intensity would have been more substantial, especially in the case of Independence. Spring is normally the windiest period in the desert, and wind serves to break an inversion.

In order to determine if inversions develop nearer to the ground than the 500 foot (152m) level indicated on Figure 4, a balloon equipped with a thermistor array was launched (Figure 5). Because of the unusual winter of 1978, data were not collected until mid-March. At this late date, few, if any, intense temperature inversions would develop. As data in Table 3 indicate, however, an inversion did exist and, in fact, the atmosphere was very stratified, even at low altitudes. The inversion on 14 March began to break down by 0900 PST as wind gusts developed and solar heating led to convective currents. By 0900, the measured air layer approached an isothermal condition. In any case, the data substantiate that inversions do develop very near the ground and probably persist for several days or more during the winter.

Figure 4 on the facing page illustrates two typical temperature inversions. Data were obtained by means of a specially equipped aircraft. No measurements were taken below 500 foot (152m) above ground level. It is probable that the top of the inversion would lie below the 500 foot (152m) level in many instances. At times, during winter, when a deep inversion develops, day time heating may not be sufficient to destroy the inversion. Synoptic conditions most characteristic of temperature inversion development include clear nights and little or no wind. Upperlevel subsidence also enhances the development of a temperature inversion.

Representative Temperature Inversions

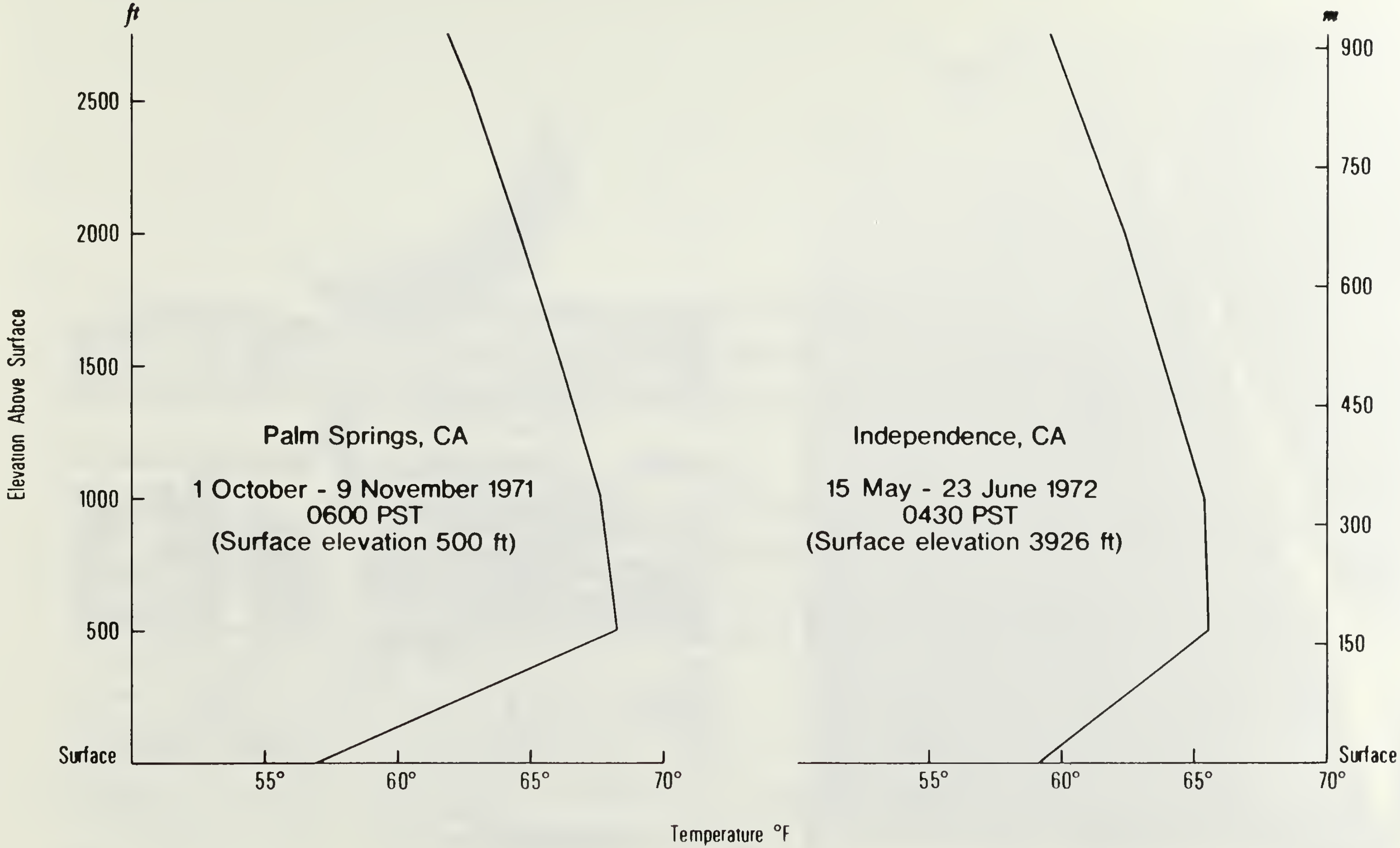


Fig 4

(Source Air Resources Board, Sacramento, CA)

Figure 5a shows the balloon prior to its launch. The balloon was filled with helium and easily lifted the thermistor array attached to it (total weight about eight pounds (3.6 kg).

Figure 5b shows the balloon in a stable position above Lucerne Dry Lake. The blurred line is the string of thermistors and connecting wires; the finer line near the left edge of the photograph is a second safety line used to secure the balloon.

With wind velocities less than 5 mph (8 kph), the balloon was stable and the thermistor array most satisfactorily measured temperatures within the air column.

5a 5b

Fig 5

TABLE 3

Balloon and thermistor array for measuring low-lying temperature inversions

14 March 1978; Lucerne Lake, California

Thermistor Elevation above Ground Elevation Feet (meters)

Time PST	7 (2.1m)	10 (3.0m)	21 (6.4m)	38 (11.6m)	67 (20.4m)	100 (30.5m)	133 (40.5m)	166 (50.6m)
0730	51.8°F 11.0°C	48.2°F 9.0°C	49.1°F 9.5°C	47.8°F 8.8°C	48.6°F 9.2°C	48.6°F 9.2°C	50.0°F 10.0°C	54.0°F 12.2°C
0745	50.9 10.5	50.9 10.5	50.4 10.2	52.2 11.2	53.2 11.8	53.2 11.8	53.6 12.0	54.0 12.2
0815	52.3 11.3	54.0 12.2	53.6 12.0	52.7 11.5	54.0 12.2	52.2 11.2	52.7 11.5	53.6 12.0
0845	54.5 12.5	53.6 12.0	53.6 12.0	53.6 12.0	53.6 12.0	53.2 11.8	53.6 12.0	53.2 11.8
0900	54.5 12.5	55.4 13.0	53.6 12.2	55.4 13.0	55.6 13.1	54.0 12.2	54.5 12.5	54.5 12.5

Wind gusts began approximately 0905.

At all times the humidity registered between 36 and 68 percent.

Wind speeds varied between 50 and 400 feet per minute (15 and 122 meters per minute).

Per Cent Hours Below Freezing

Numerous topical data are presented in Table 2. Several of these parameters are only of casual interest to the resource manager. All terms are explained in the Appendix. Of particular interest here are the data on percent of annual hours below freezing. These data closely agree with the scanty published data and correlate well with the inversion analysis/ data presented in Table 1. These data can be used to approximate temperature inversion development and persistence (valley locations). Almost all stations in the low desert have values less than one percent while stations located in the high desert record percent values over a wide range: one to seven percent, depending upon the specific location. Elevation represents the primary control on the value of percent of annual hours below freezing, although local factors (exposure) often play an important role. Reference was already made to the high value of White Mountain 2 where fully 63 percent of the annual hours fall below freezing. Data from Arizona and Nevada are given for comparative purposes.

The graph in Figure 6 approximates a parabolic curve, although a few notable exceptions to this general description exist. Randsburg, because it is situated at an elevation higher than the surrounding area, is not susceptible to temperature inversion development or cold air drainage. Thus, it records fewer annual hours below freezing than stations with the same approximate elevation.

Almost all of the low desert stations have less than one percent of their annual hours below freezing; they cluster much more than stations located in the high desert where elevations are much more variable. Note that Death Valley, because of its exceptionally low elevation, especially for stations located in the High Desert, has less than two percent of its

Figure 6 shows the relationship between percent of annual hours below freezing and elevation. The relationship approximates a parabolic curve. Deep Springs was the highest elevation station used in the graph. Mountain stations are unique in slope and exposure so that data from them follow no set pattern. For example, White Mountain 2, at 12,100 feet (3,688 m) has more than sixty-three percent of its annual hours below freezing.

The percent hours below freezing are all calculated values. The technique used is based on normal probability theory and observed hourly temperature data from numerous stations located world-wide.

Elevation vs. Percent Annual Hours Below Freezing

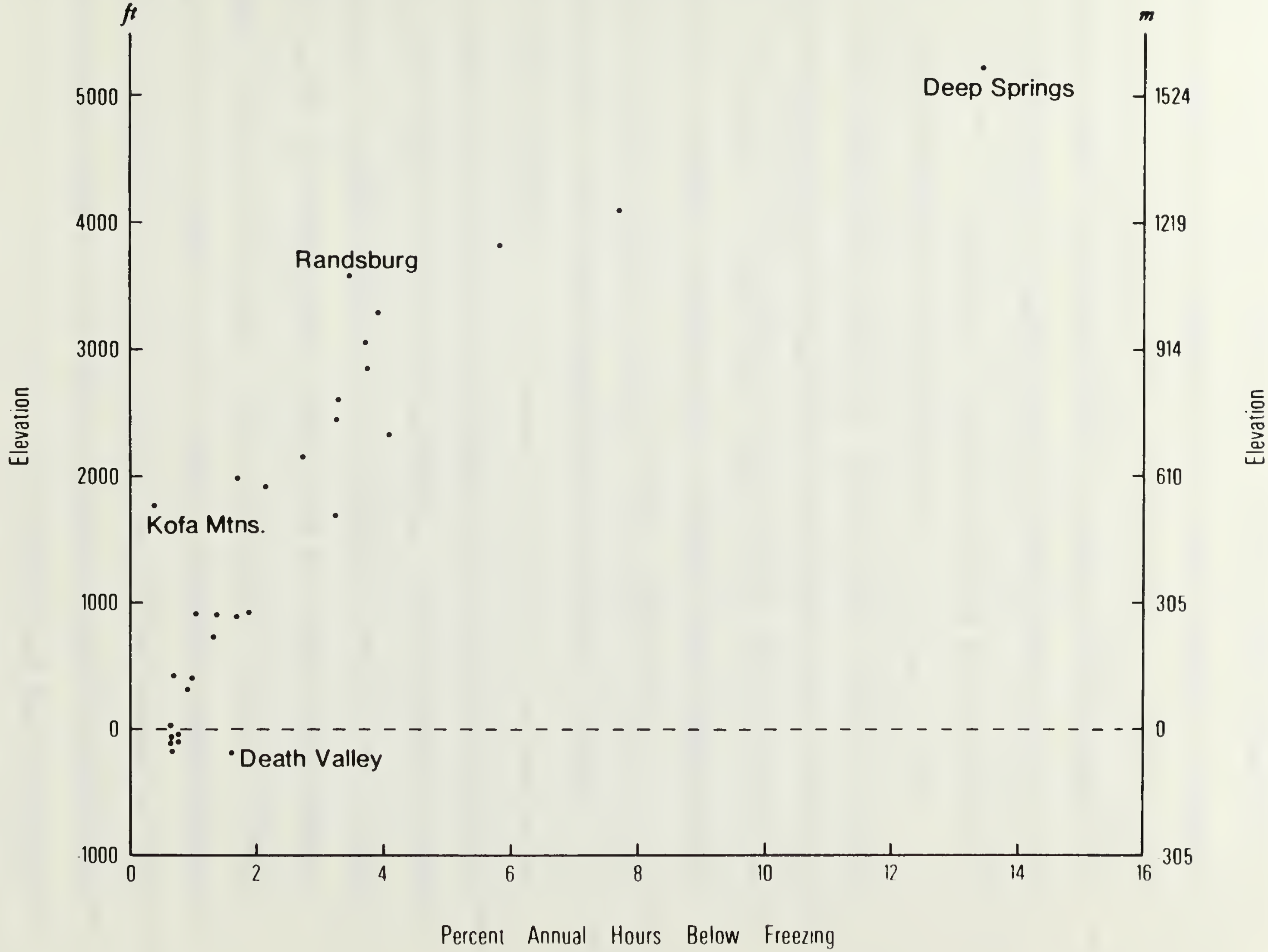


Fig 6

annual hours below freezing. Death Valley may be considered a thermal microcosm in the Basin and Range portion of the high desert because of its location relative to air movement from the south,more anon. Twentynine Palms, although not identified on the graph, also has less than two percent of its annual hours below freezing. In fact, Twentynine Palms and Daggett would fall nearly on a border separating the High and Low Desert if temperature and elevation criteria were used. Their geographical position, and that of Death Valley, places them in sites influenced by warmer air masses moving up from the Gulf of California.

With the exception of White Mountain 2, given to represent an extreme case of a desert alpine station, the only station having more than ten percent of its annual hours below freezing is Deep Springs, located near the northern border of the CDCA. Deep Springs is located in a reasonably isolated area nearly one mile (1.6 km) above sea-level. Ten percent of the annual hours represents about 36 days, or slightly more than one month.

Column 4, giving the temperateness index, is of some interest. Temperateness is a statistical parameter that indicates the degree of climatic equability of a place. The highest possible value is 100 and would indicate a place that has a mean temperature equivalent to that of the earth as a whole (57°F, 13.9°C) and does not vary between seasons. The higher the temperateness value, the more equable the climate. As the mean annual temperature departs from the mean global temperature and/or as temperature extremes between seasons increase, the less temperate is the climate. Note the values of stations located within the Low Desert are less variable than values of stations located within the High Desert where elevation ranges are much more substantial.

Temperature Graphs

Figure 7a-p present temperature curve plots for selected stations in the CDCA or nearby locations. All curves were plotted after statistical analyses of mean monthly temperatures and mean annual temperature. Appendix B includes all station statistics, as well as the critical temperatures presented in Table 1. The temperature curves in Figure 7a-p are intended to illustrate typical temperature regimes of desert stations. The three dashed lines on the plots indicate temperatures of 43.6°F (6.4°C), 50°F (10°C) and 86°F (30°C). (The number of days per year with these mean daily temperatures are given in Table 1).

Several interesting conditions can be gleaned from visual analyses of the temperature curve plots. First is the thermal lag present in autumn. Every station plot illustrates the lag, although some are much more pronounced than others. Some of the most pronounced temperature lags are noted at Barstow, Twentynine Palms, Needles, Iron Mountain, Yuma and Palm Springs. The thermal lag retards the decrease of air temperature after the autumnal equinox.

Each station plot also illustrates a slight depression in the temperature rise during spring and early summer. This depression is thought to be due to the typical influx of moist maritime air during the transistion season. The cloudy and dreary days of May and June are well known to the coastal dweller in California, but it also appears that the influence of the maritime air extends into the desert. Naturally, some stations have a greater temperature depression than others. Of particular significance are the temperature plots for Palmdale, Victorville and Palm Springs. Each of these stations is relatively open to the movement of air from the coastal lowland. In the case of Palmdale, maritime air moves up and through Soledad

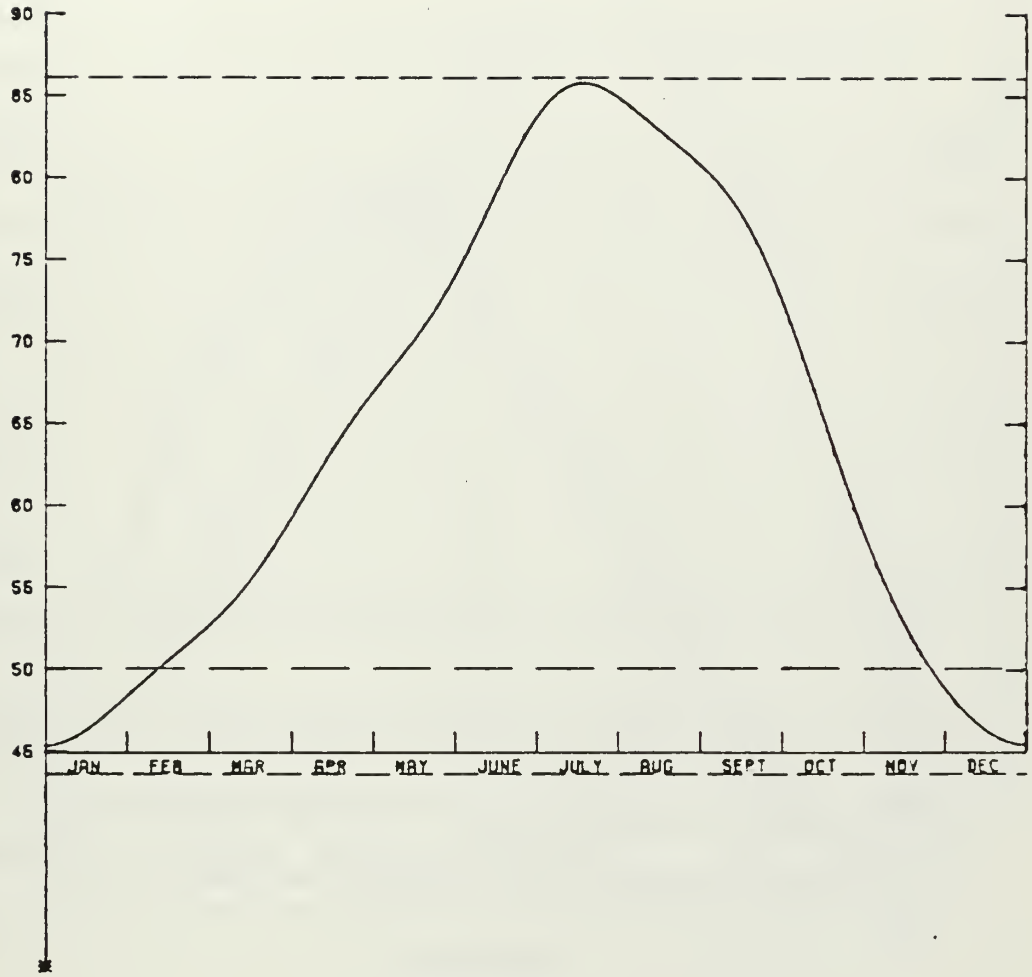
Figure 7 a-p

The following graphs present harmonic analysis of mean monthly temperatures for selected stations within or near the CDCA. Several graphs from Arizona and Nevada are included for comparative purposes. All calculated data are included in Appendix.

Note that the ordinate scale varies with each plot.

The stations selected are:

a) Barstow	i) Palmdale
b) Bishop	j) Palm Springs
c) Death Valley	k) Trona
d) Deep Springs	l) Twentynine Palms
e) El Centro	m) Victorville
f) Iron Mountain	n) Kofa Mountains, AZ
g) Lucerne Valley	o) Yuma, AZ
h) Needles	p) Las Vegas, NV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BARSTOW

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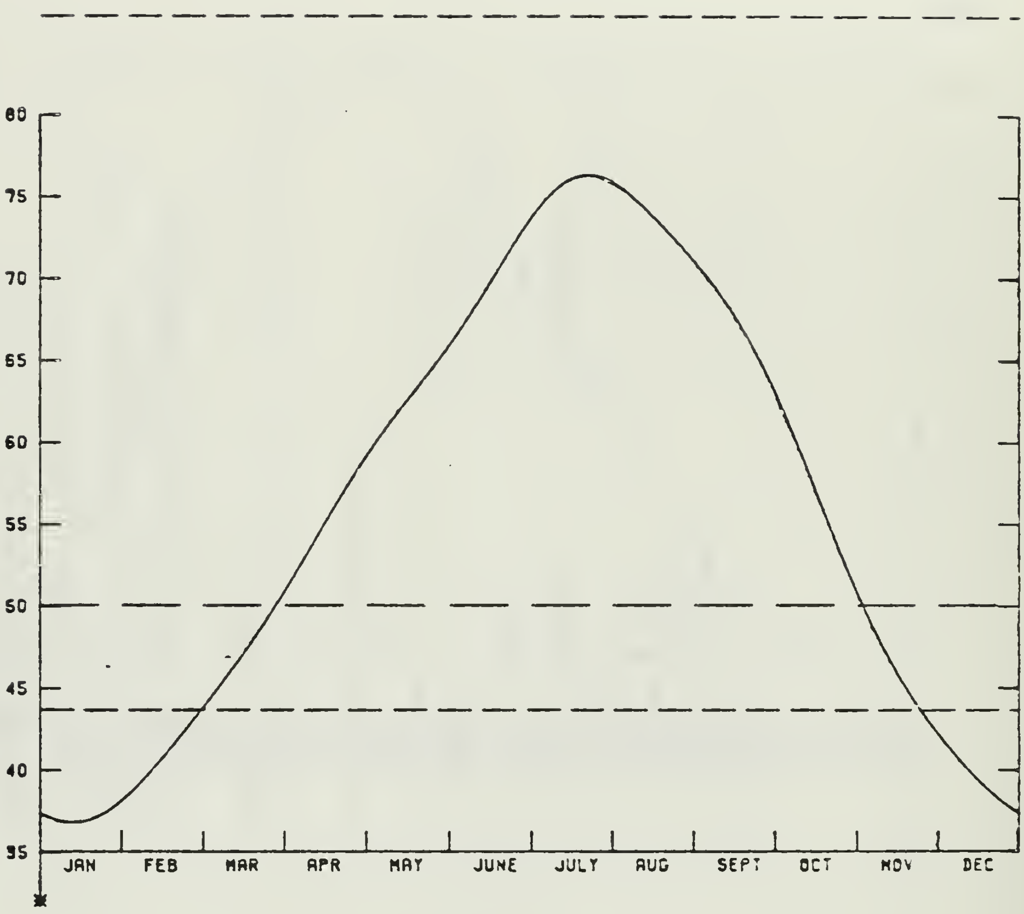
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BISHOP AP

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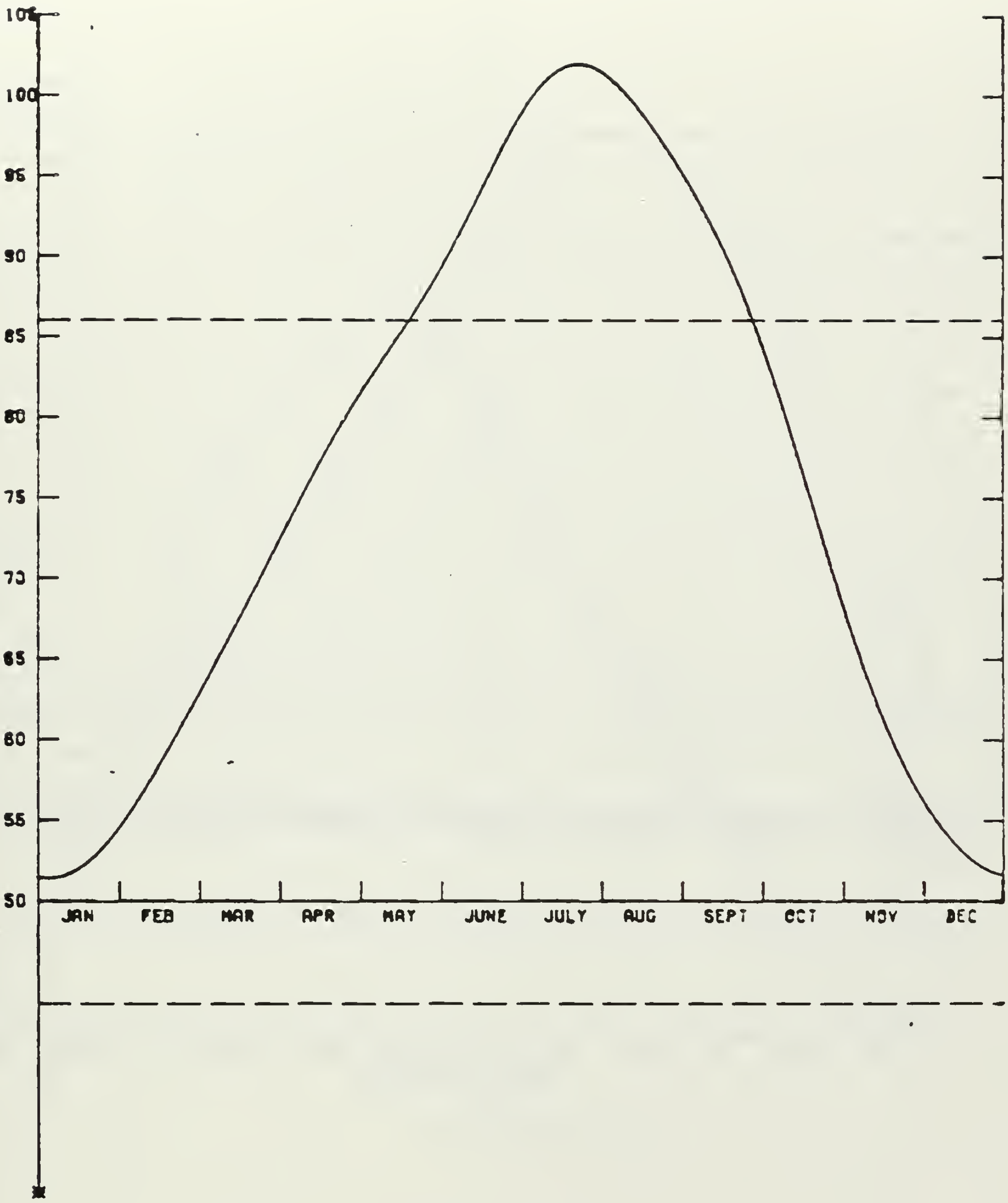
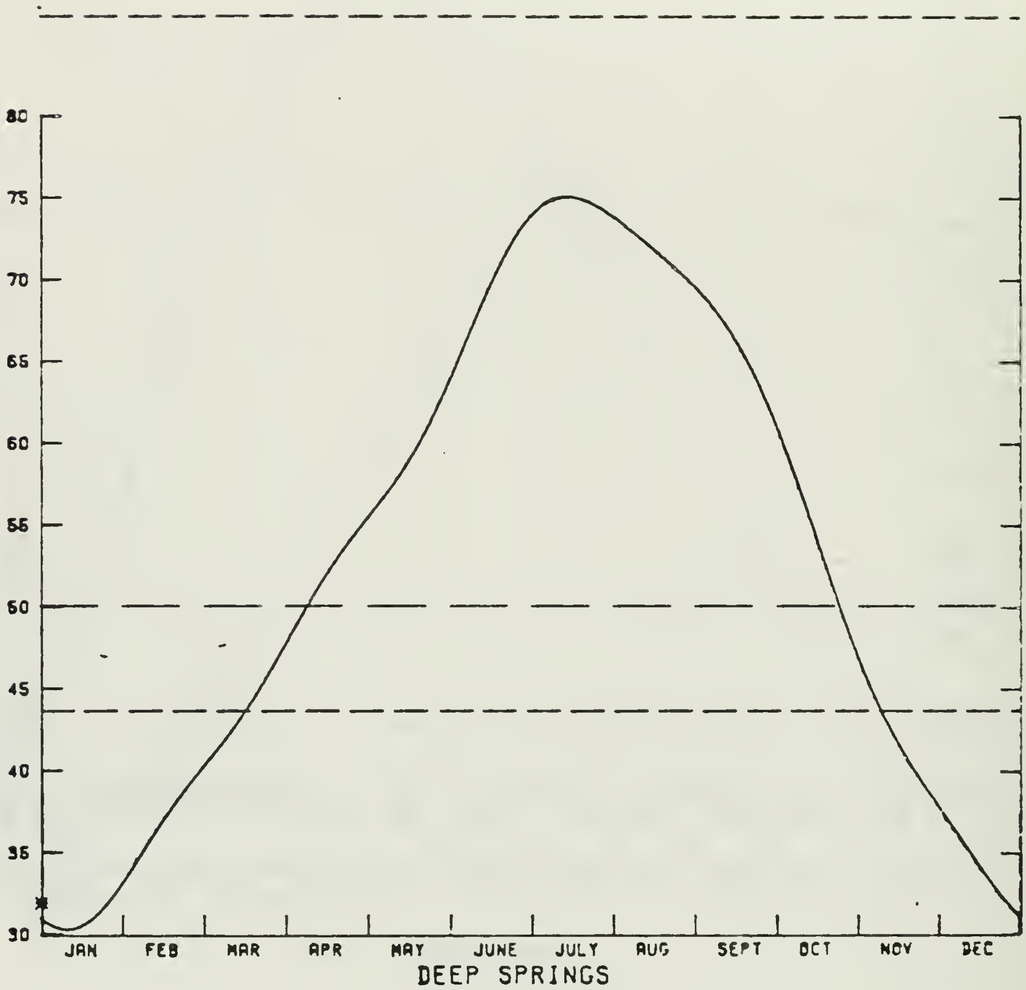


DEATH VALLEY

7c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DEEP SPRINGS

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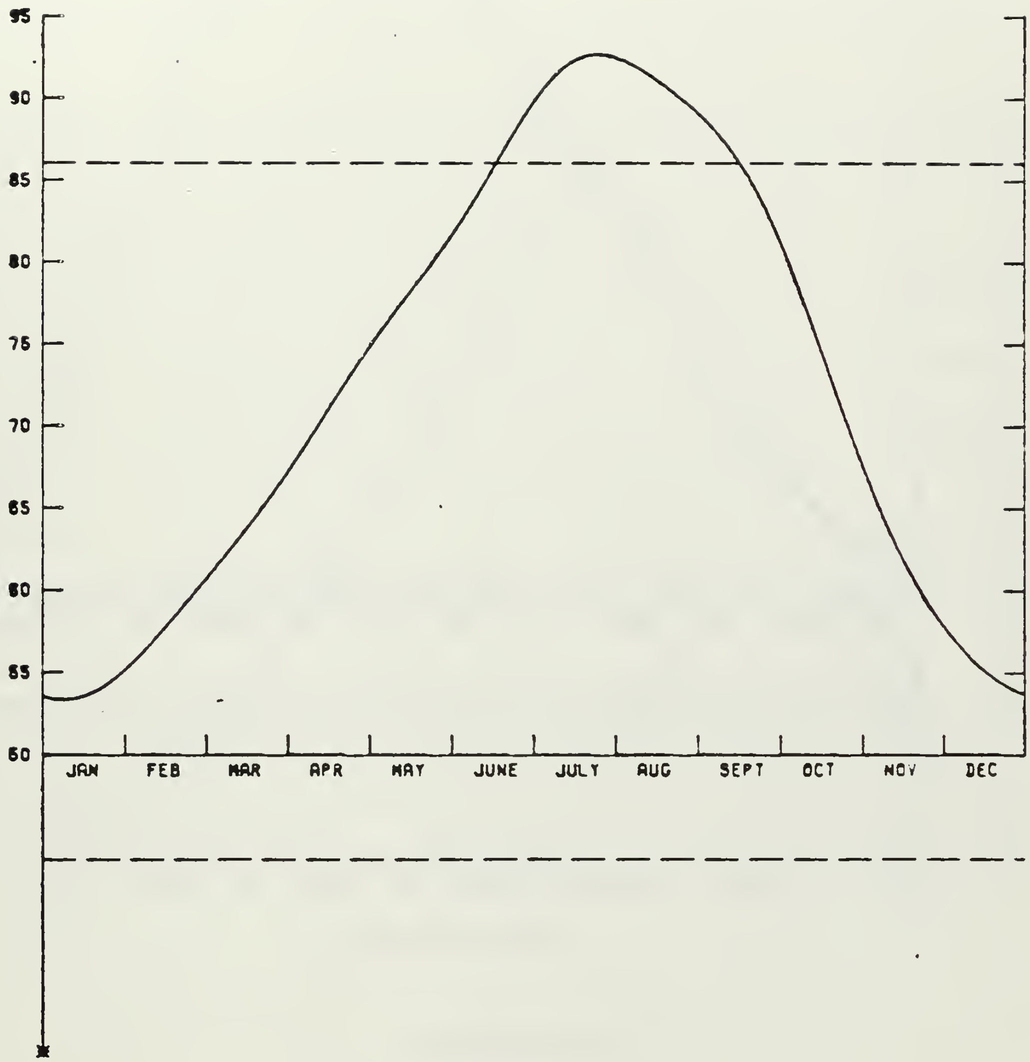

EL CENTRO 2 SW

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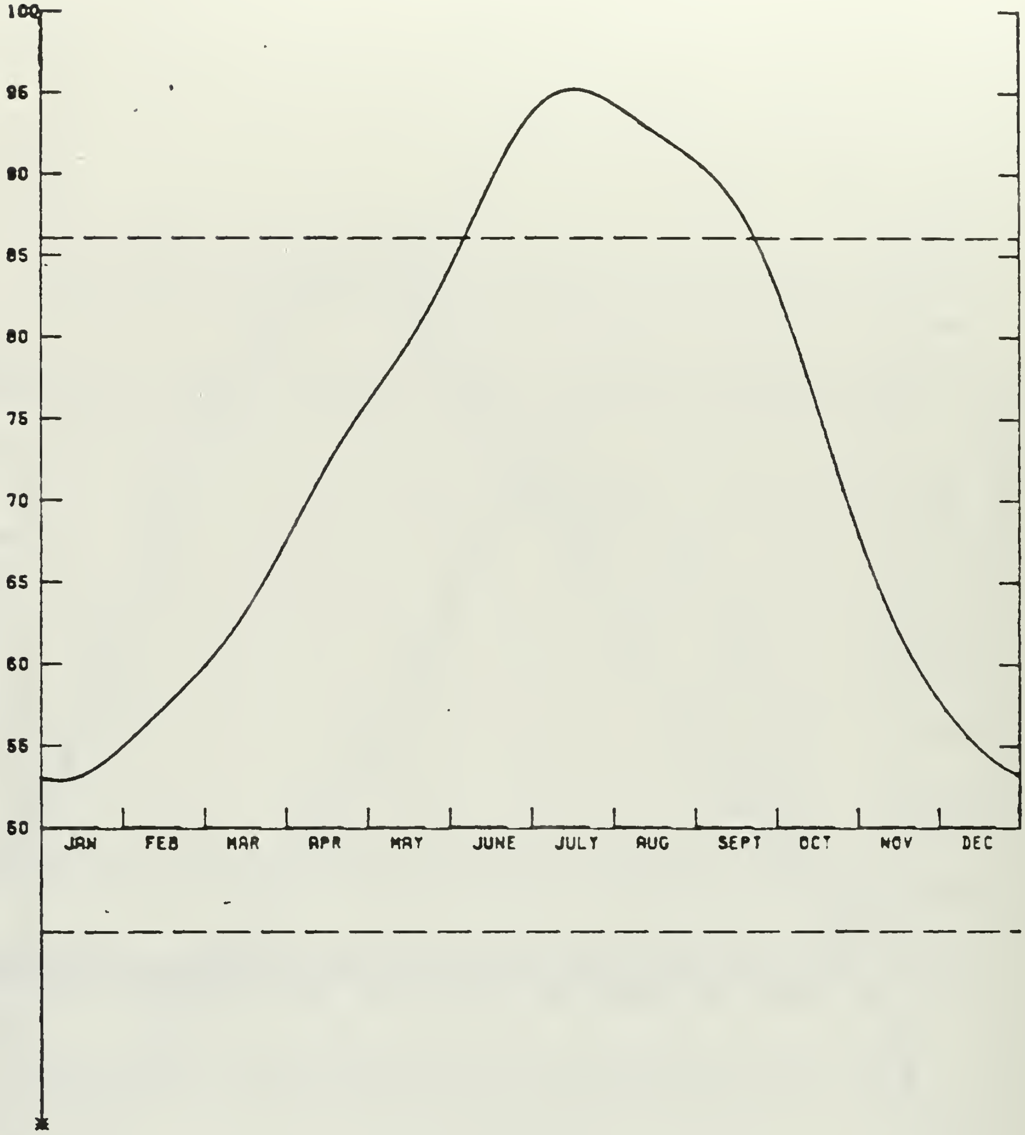

IRON MOUNTAIN

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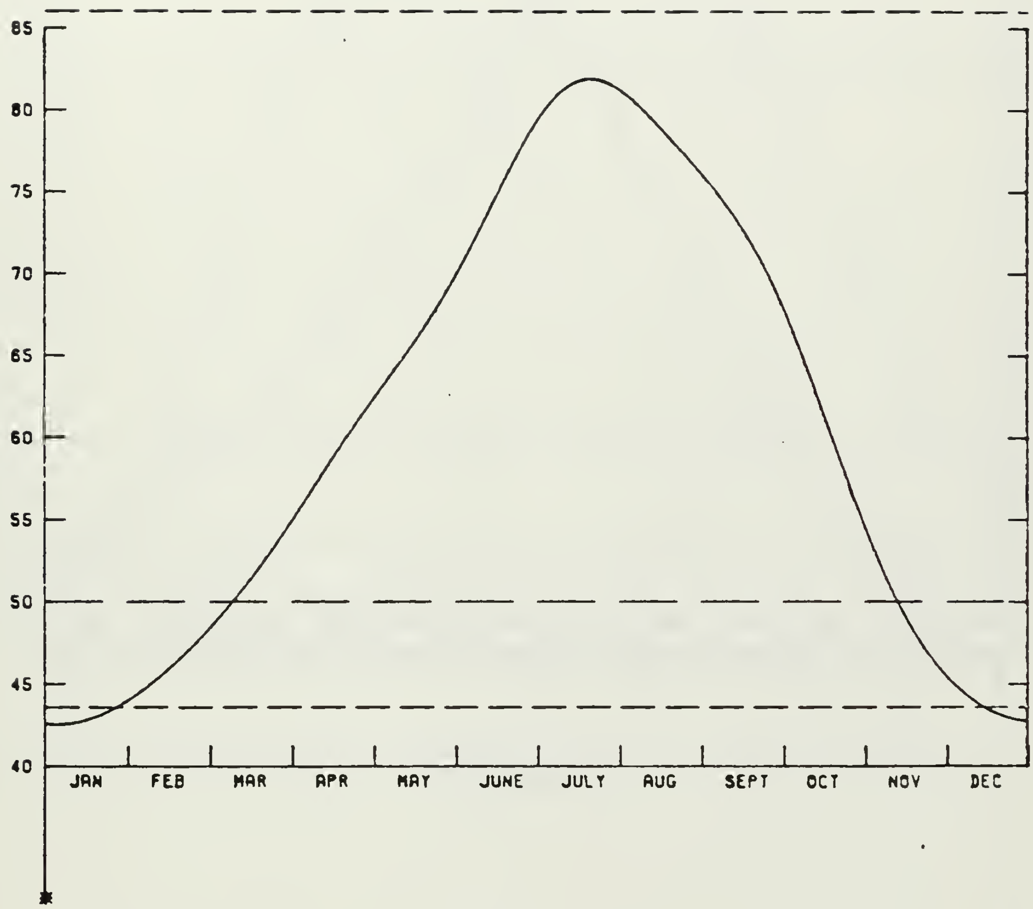

LUCERNE VALLEY

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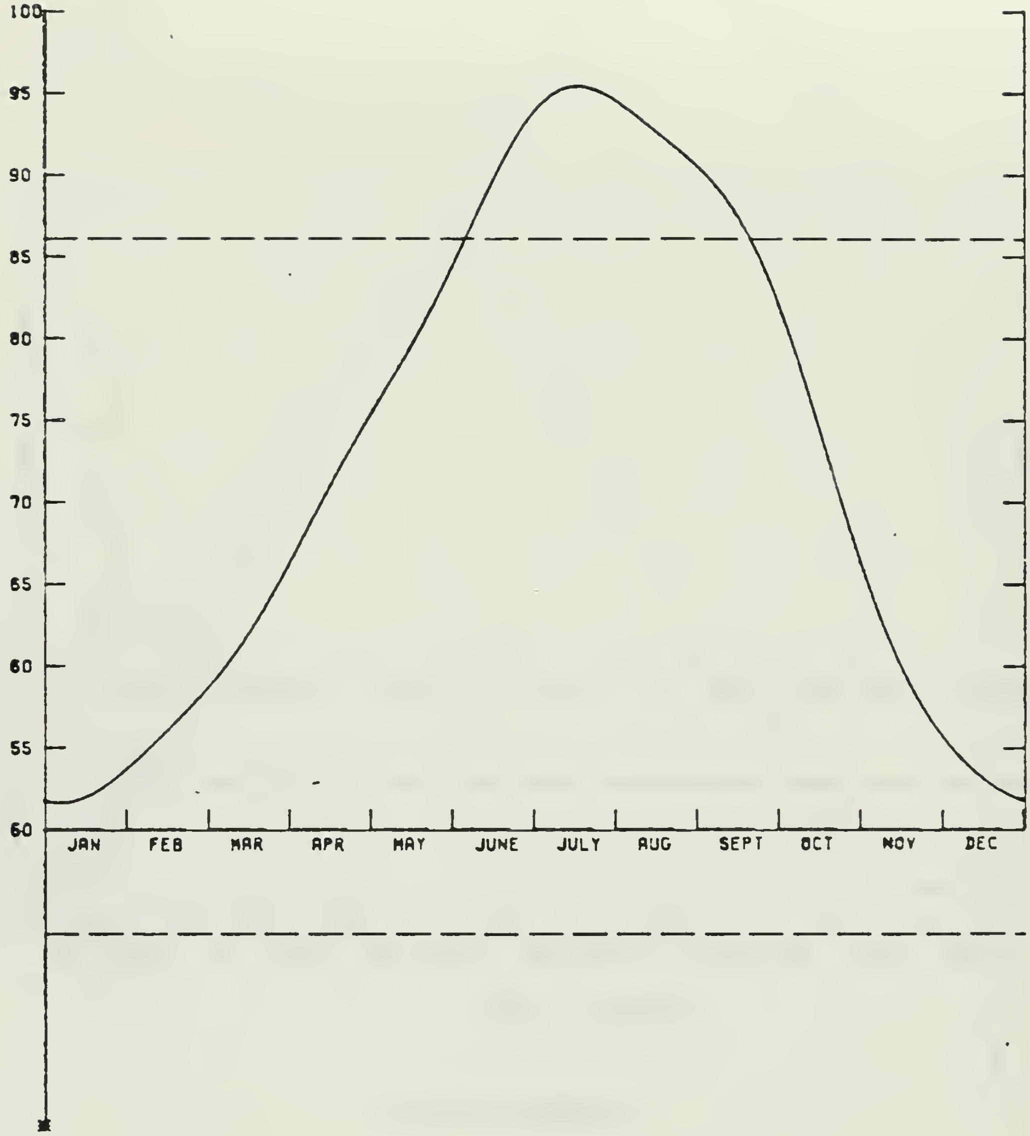
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NEEDLES

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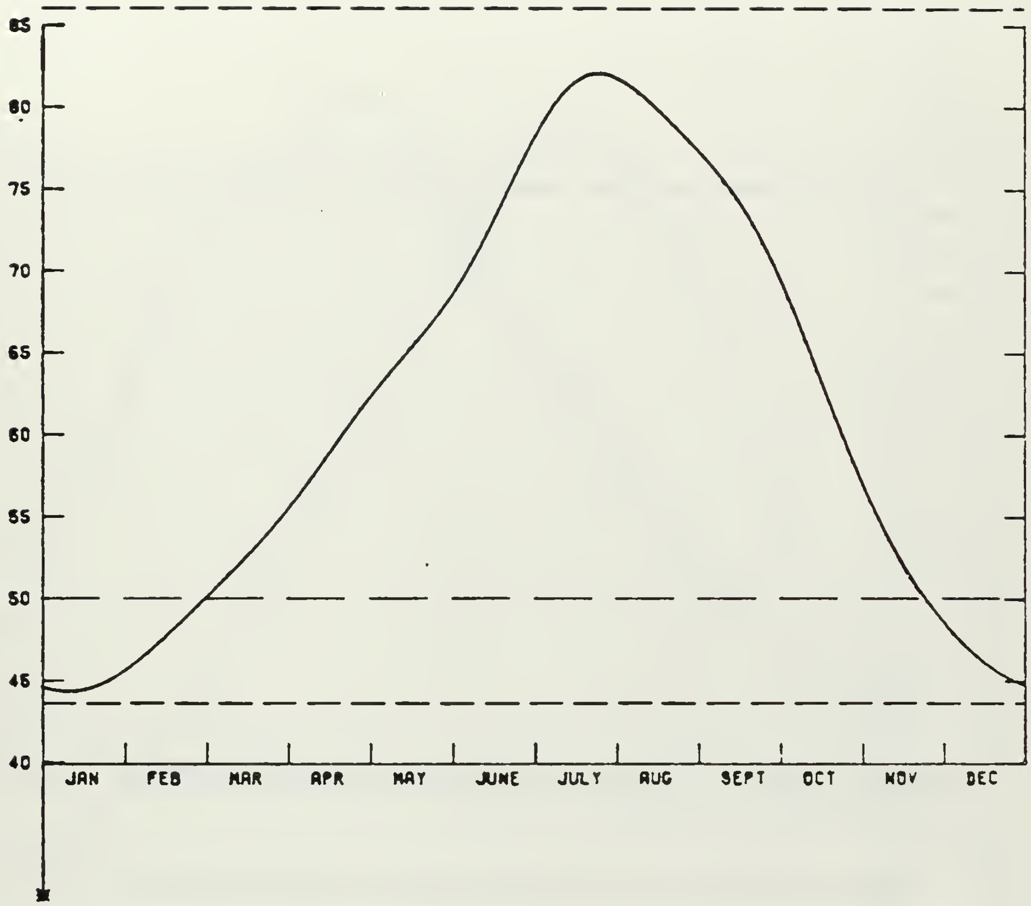
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PALMDALE

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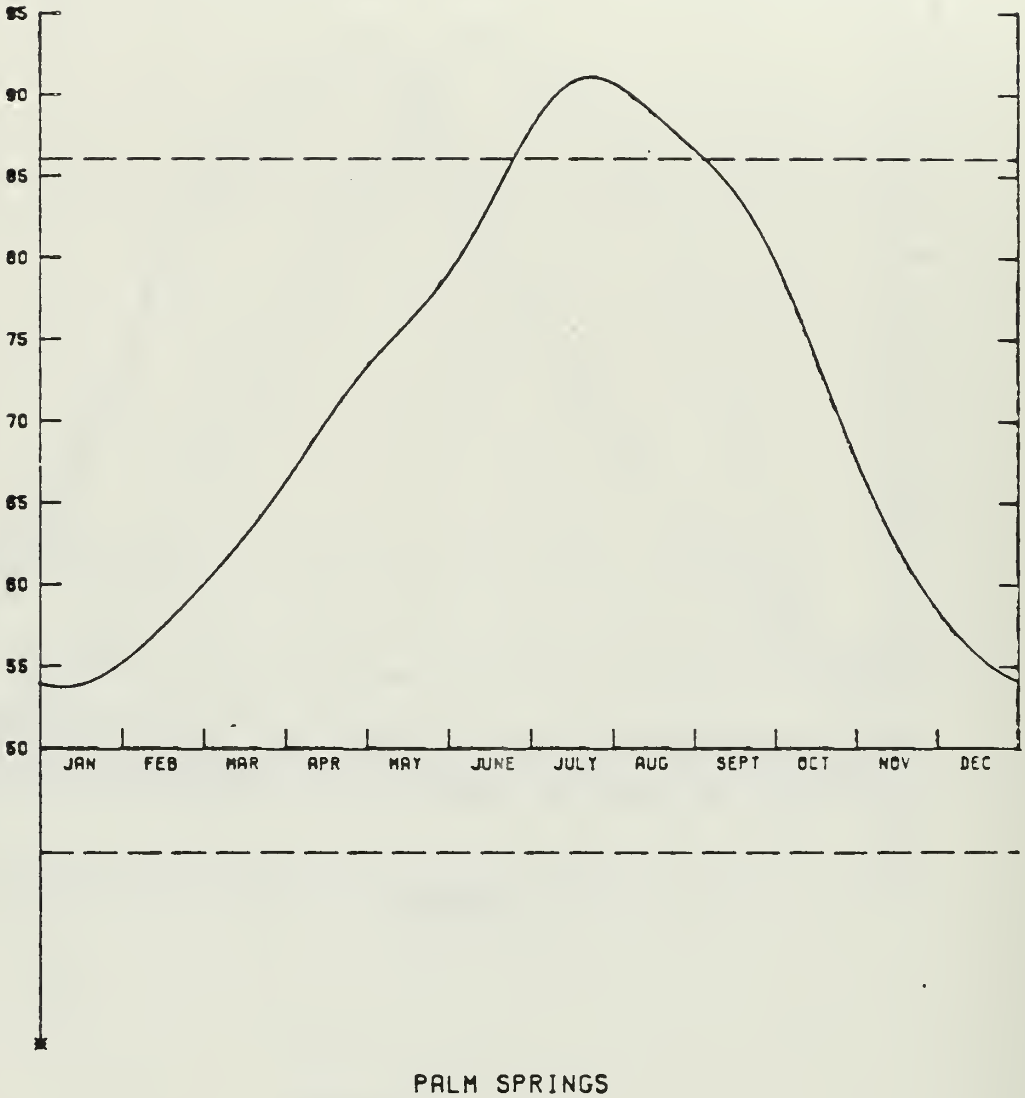
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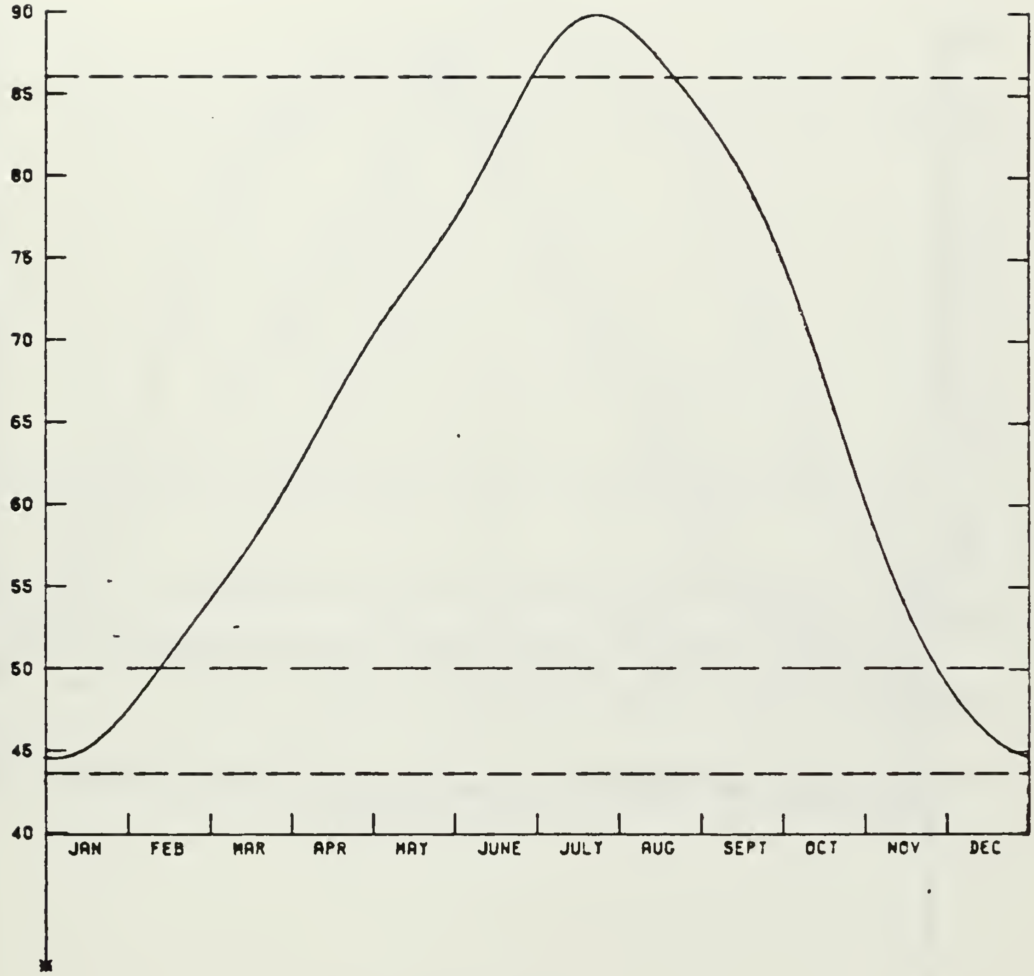
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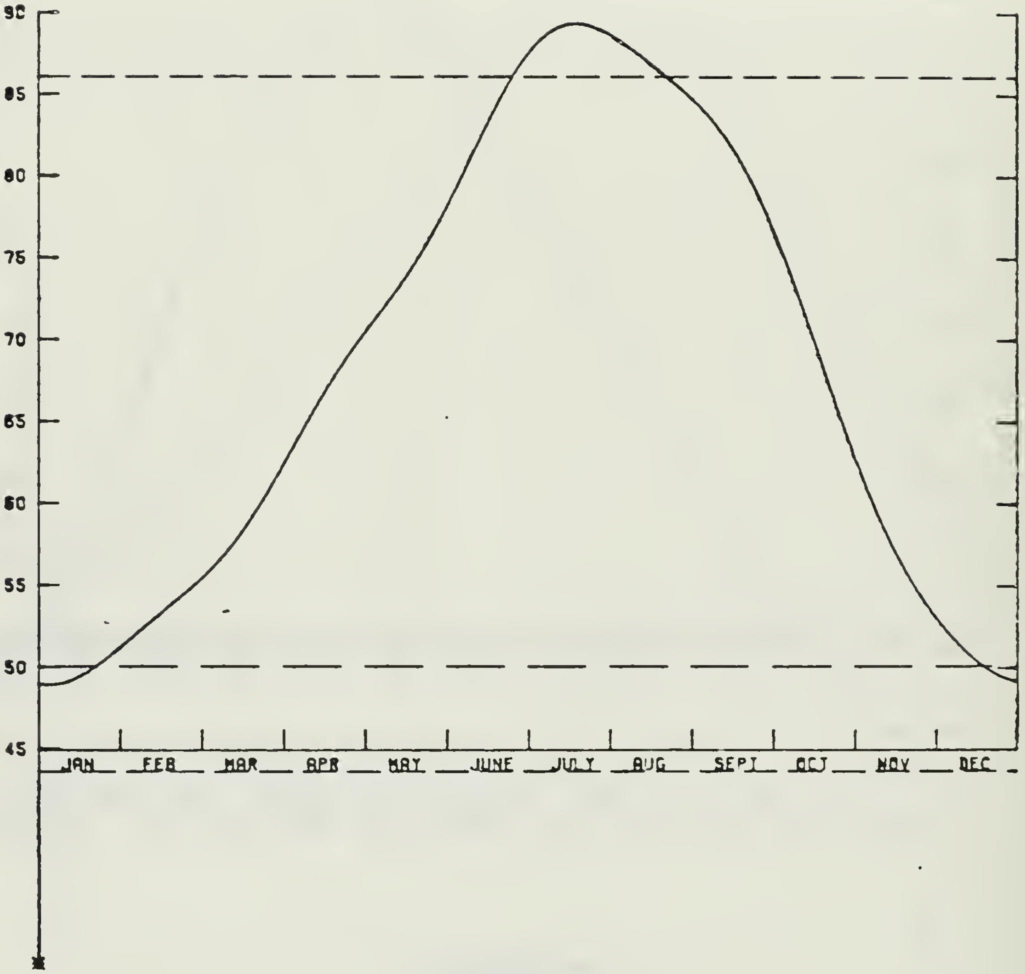
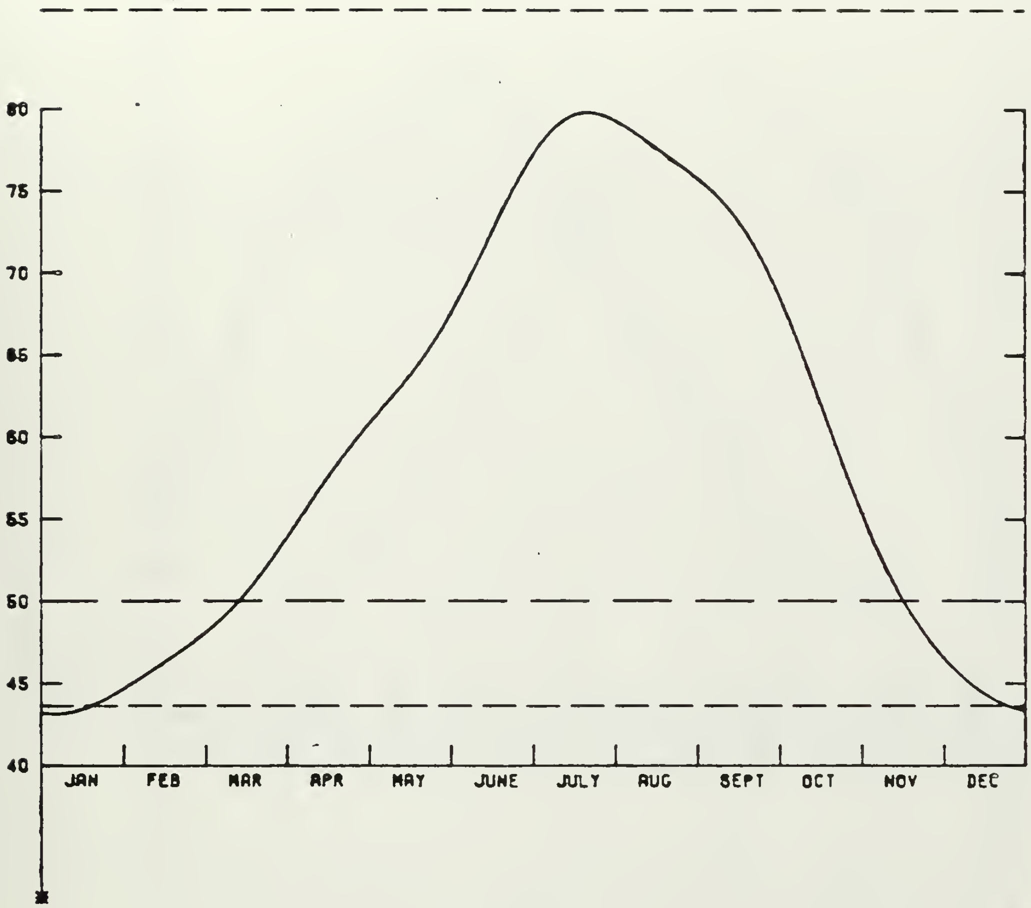
TRONA

7k



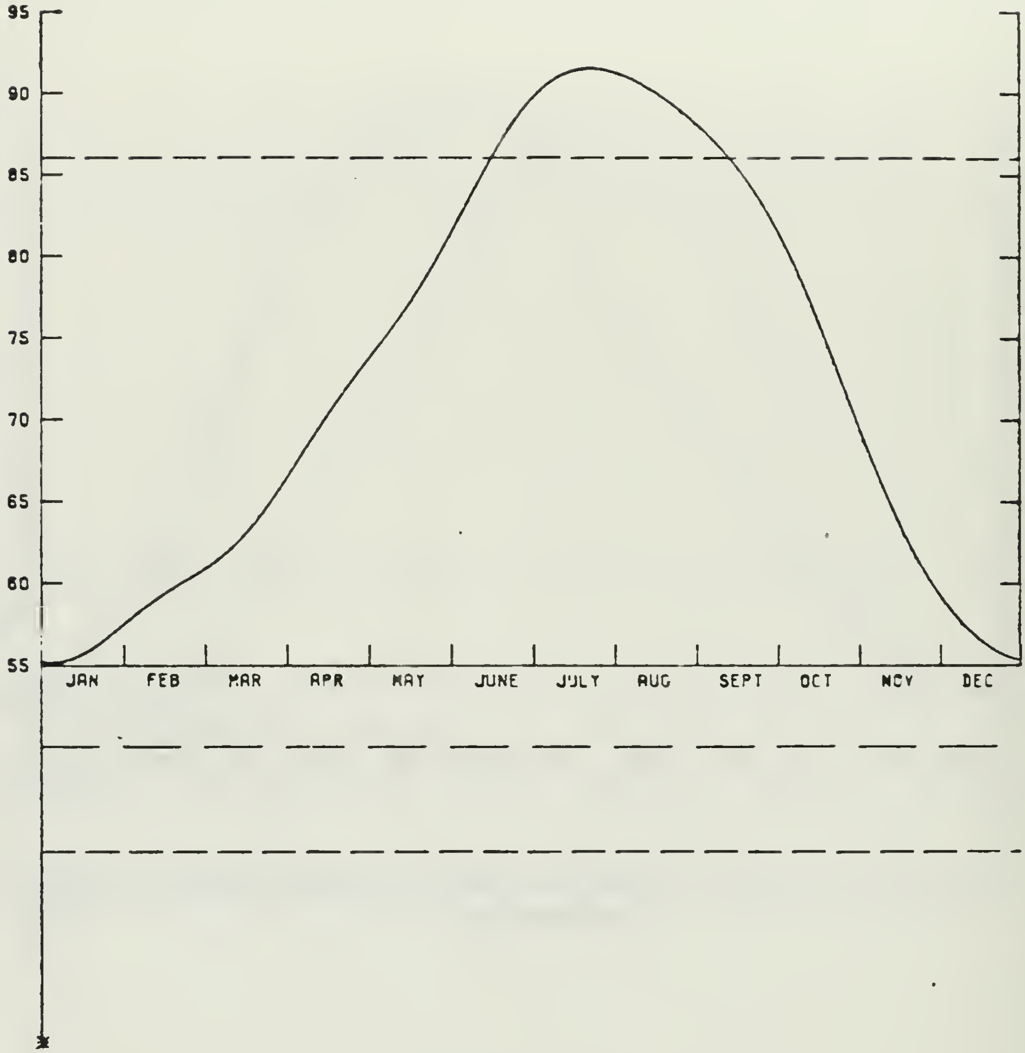
TWENTYNINE PALMS

71



VICTORVILLE

7m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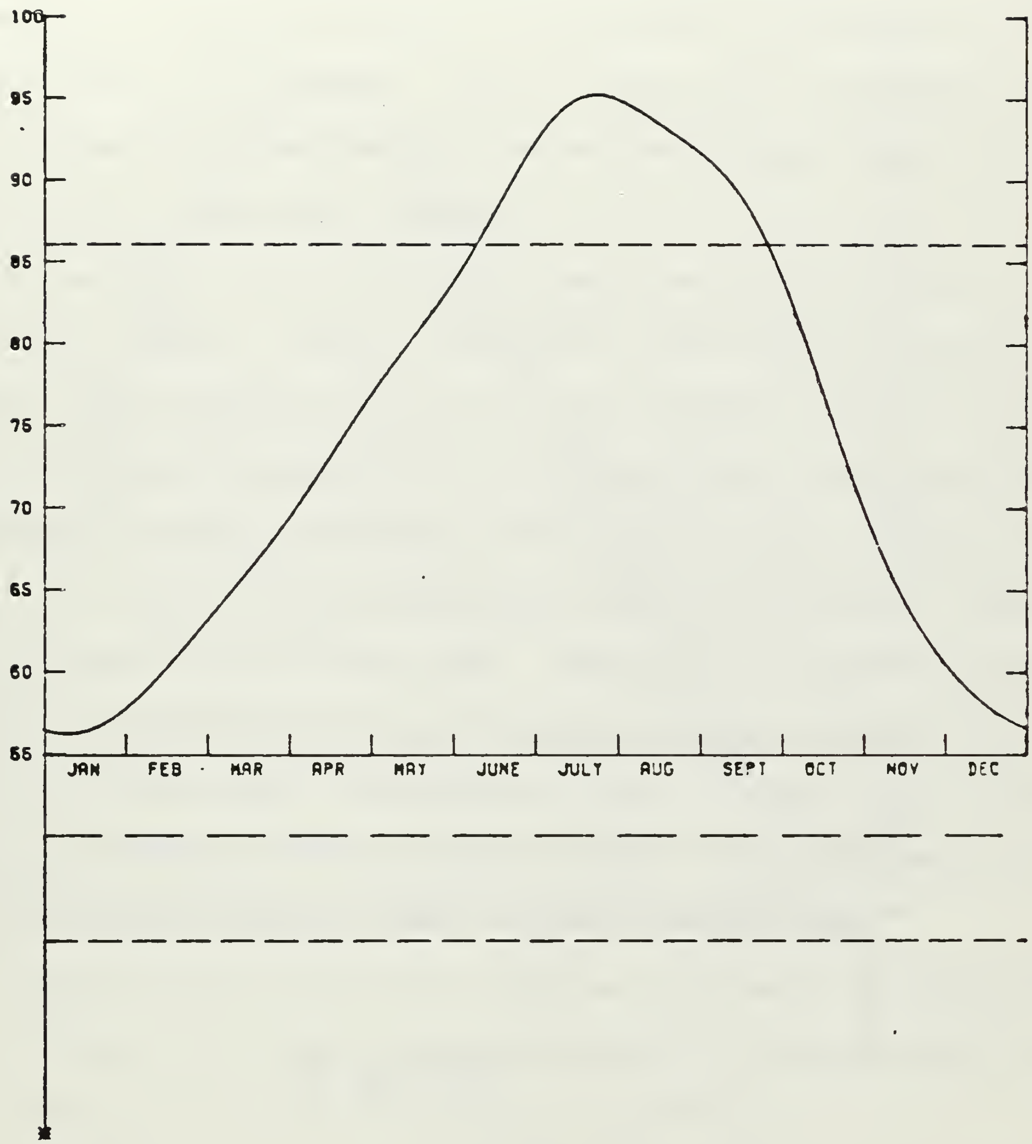

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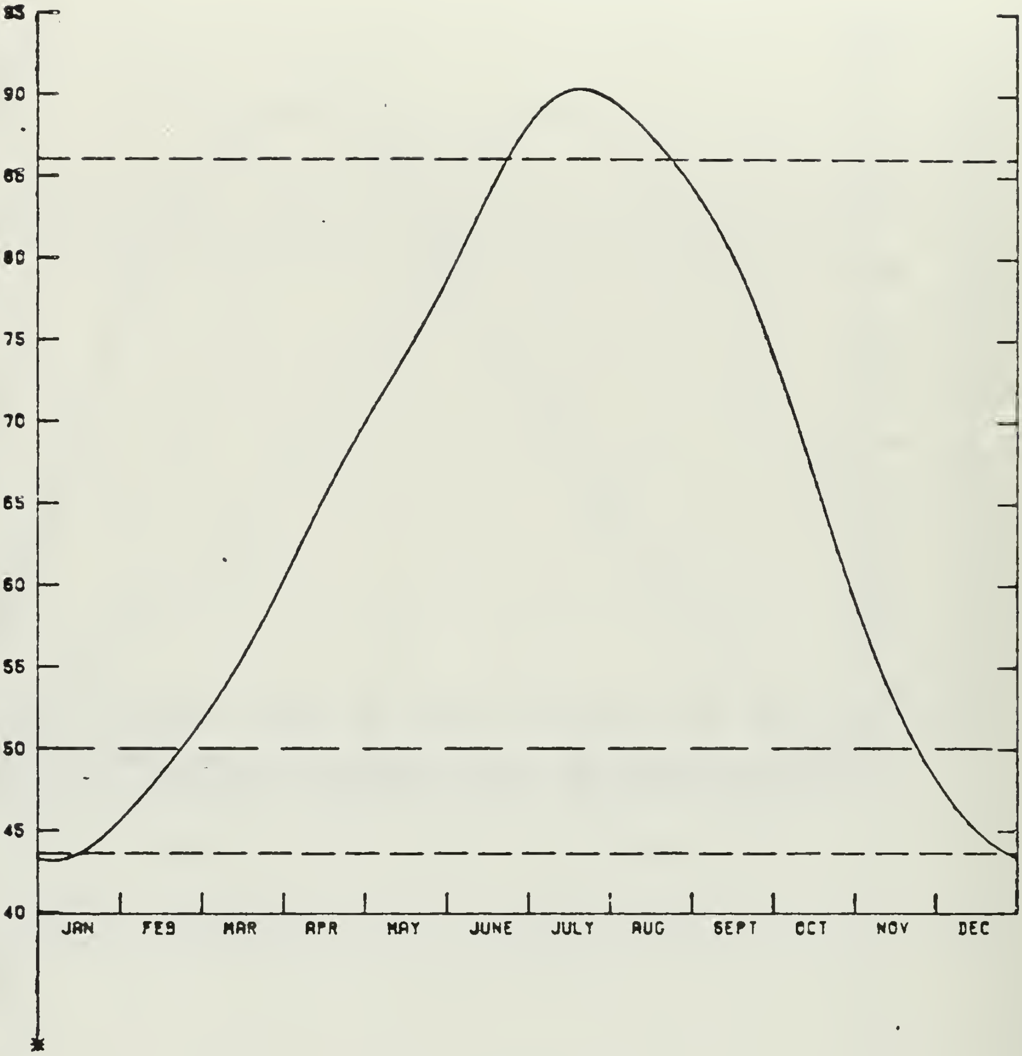


LAS VEGAS AP

7p

Canyon; at Victorville, maritime air moves up and through Cajon Pass and extends well into the Mojave Desert. On occasion, the movement of this air has been observed at China Lake and Haiweee Reservoir. In fact, the curve plots for Trona and Bishop AP show the same depression in the rise of temperature during May and June. Palm Springs quite regularly receives a strong influx of maritime air from the coast through San Gorgonio Pass. During May and June, this influence can be quite strong, as the temperature curve plot for Palm Springs indicates.

The movement of this air into the desert can advect pollutants from the coastal lowland. Recently, researchers at NWC China Lake studied deteriorating desert visibility and came to a preliminary conclusion that most of the pollutants were generated in the coastal lowland and advected into the desert (Paul Owens and Raymond Kelso, NWC China Lake, personal communication). In order to substantiate their tentative conclusion, a time lapse film was made of the Cajon Pass area. Advection of polluted air was well documented. Of interest was that the marine air (sea-breeze) did not move through Cajon Pass until late afternoon or early evening. Thus, many pollutants were advected into the desert at dusk or during the evening when it was not directly observable (Robert Hicks and James Huning).

Stations located some distance from the coast show a decreasing influence of marine air on their temperature curves, but in most cases, a trace of the moist air can be seen (Las Vegas, Death Valley).

As is true of most arid or semi-arid environments, the temperature curve plots are sinusoidal, reflecting the lack of high moisture amounts or cloudy skies. Greater humidity or cloud conditions would depress the amplitude of the temperature curves. As represented by the curves, the range of annual temperature determined from mean monthly temperatures, can

be substantial.

Examination of the apex of the temperature curve plots shows that the occurrence of late afternoon thunderstorms may be represented in the temperature traces. Stations in the eastern Mojave (Needles, Iron Mountain) appear to show an actual dip, rather than just a flattening in the curve, from July to September. This dip is likely associated with increased cloud cover and thunderstorm activity, both of which would depress the temperature. Comparison with the plots of Trona, Death Valley or Lucerne Valley, for example, shows no significant dips in the temperature curve. A more thorough study of temperature and precipitation correlation would be necessary before a complete cause and effect of the harmonic analysis temperature plots could be given. However, the indications are strong enough to warrant a more complete study. In addition, an examination of the incidence of summer precipitation is warranted by other factors, as will be addressed in the section on precipitation characteristics.

Freeze-Free Period

Table 4 presents data, taken from published sources, on the number of days per year that the temperature drops to or below freezing, or exceeds 90°F (32.2°C). These data should be of use to the planner and used in conjunction with the calculated critical temperatures presented in Table 1. As indicated by the data, stations located in or near the low desert record few days with temperatures dropping below freezing. These data also serve to further substantiate the previous discussion on temperature inversions with the CDCA (e.g., the data for Lucerne Valley).

Data from Table 4 illustrates all locations in the CDCA are susceptible to freeze during a part of the year. However, formost of the CDCA, excluding the mountain ranges, the freeze-free period extends for at least 200 days per year. Only in the western Mojave does the freeze-free period drop to 200-250 days per year, for the rest of the CDCA, the freeze-free period exceeds 250 days per year, with most stations in the Colorado Desert and much of the eastern portions of the east Mojave having 300-350 days per year freeze-free. An area focusing on Parker and eastward to Hayfield Pumping Plant has the highest number of freeze-free days in the CDCA, more than 350 days per year. Not surprising, because of its low elevation, Death Valley has the longest freeze-free period in the High Desert; more than 300 days per year are freeze-free. The shortest freeze-free period in the CDCA, excluding the mountains, is found in the more northerly portions. For example, in the vicinity of Deep Springs College, only about 140 days per year are freeze-free.

To be sure, local conditions can cause a station to have considerably more freeze days than the above general description would suggest. In locations where temperature inversions commonly develop, the number of

Table 4

NUMBER OF DAYS PER YEAR THAT THE TEMPERATURE DROPS
BELOW 32°F OR RISES ABOVE 90°F

Station	32 F (0C)	90F (32.2C)	Station	32 F (0C)	90F (32.2C)
Backus Rch	67	116	Inyokern	65	132
Barstow	57	136	Iron Mtn	2	168
Bishop Ap	147	102	Lancaster	80	111
Blythe	12	185	Lucerne Valley	104	121
Blythe Ap	4	176	Mecca	12	178
Borrego Springs	19	174	Mono Lake	163	9
Brawley	7	182	Needles Ap	6	165
Daggett Ap	36	142	Palmdale Ap	81	106
Deep Srpings	155	55	Palm Springs	12	181
Eagle Mtn	1	154	Randsburg	33	105
El Centro	15	185	Sandberg	54	23
Fairmont	29	59	Tahoe City	219	0
Greenland Rch	8	197	Tehachapi	100	36
Haiwee	73	77	Thermal Ap	12	180
Hayfield	16	155	Trona	47	148
Imperial	5	177	Twentynine Palms	29	152
Indio Date Garden	15	191			

freeze-days can be considerably more, although the area affected is usually quite small (small basin or valley, playa floor).

PRECIPITATION CHARACTERISTICS

Precipitation amounts in the entire CDCA are low. Only at the higher elevations in the mountains surrounding the CDCA do precipitation totals become large. Evaporation always exceeds precipitation during the year.

Precipitation recording stations in the CDCA are identified on Figure 8. A number of stations that are operated by the U.S. Geological Survey, National Park Service, and several local agencies are not shown. With a few exceptions, only those stations that have reasonably long precipitation records are mapped (the name of each station mapped on Figure 8 may be keyed to the station listing on the two pages preceeding Figure 8). Several stations included on Figure 8 are maintained by the Department of Water and Power, City of Los Angeles. As Figure 8 illustrates, meteorological stations are lacking in the northern, central and southeastern portions of the CDCA. To be sure, some of the area lacking sufficient meteorological stations is under the jurisdiction of the military or National Park Service.

The CDCA receives moisture by two basic circulation patterns, winter cyclonic activity and summer convectional storms. Both of these patterns are described in the following two sections.

Figure 8

PRECIPITATION RECORDING STATIONS IN OR NEAR THE CALIFORNIA DESERT (AS OF MARCH 1977)

1. Adelanto (17)
2. Aqua Caliente Springs
3. Alabama Hills
4. Apple Valley (17)
5. Baker (6)
6. Barstow (64)
7. Barstow
8. Bermuda Dunes
9. Big Pine Power
10. Bishop Creek Intake (64)
11. Bishop Airport
12. Blythe (68)
13. Blythe 7 W
14. Blythe CAA Airport (36)
15. Boron
16. Borrego Desert Park (31)
17. Boulevard No. 2 (8)
18. Brawley 2 SW (68)
19. Cain Ranch
20. Cajon West Summit
21. Calexico 2 NE (55)
22. Calipatria
23. Camp Independence
24. Cathedral City
25. Conway Summit
26. Cottonwood Creek
27. Cottwood Gates
28. Crawford Ranch
29. Cushenbury Ranch
30. Daggett Airport (37)
31. Dale Dry Lake
32. Death Valley (65)
33. Deep Canyon Laboratory (14)
34. Deep Springs College (28)
35. Desert Center 5 NE
36. Desert Hot Springs
37. Eagle Mountain (43)
38. Edwards Air Force Base
39. El Centro 2 SSW (45)
40. Ellery Lake (51)
41. El Mirage Field (6)
42. El Mirage Airport
43. Fairmont Reservoir (67)
44. Gem Lake (50)
45. Glacier Lodge
46. Gold Rock Ranch (13)
47. Goldstone Echo 2 (4)
48. Haiwee Dam South (54)
49. Hayfield Pump Plant (43)
50. Hesperia
51. Hesperia FSS (17)
52. Hi Vista
53. Holtville
54. Imperial (58)
55. Imperial Airport (15)
56. Independence Law and P Office
57. Independence LA Aqueduct Intake (91)
58. Indio
59. Indio US Date Garden (99)
60. Inyokern (28)
61. Inyokern FS
62. Inyokern Armitage (36)
63. Iron Mountain (42)
64. Ivanpah County Yard
65. Jacumba
66. Johnson Valley
67. Joshua Tree (3)
68. Kee Ranch

(Continued)

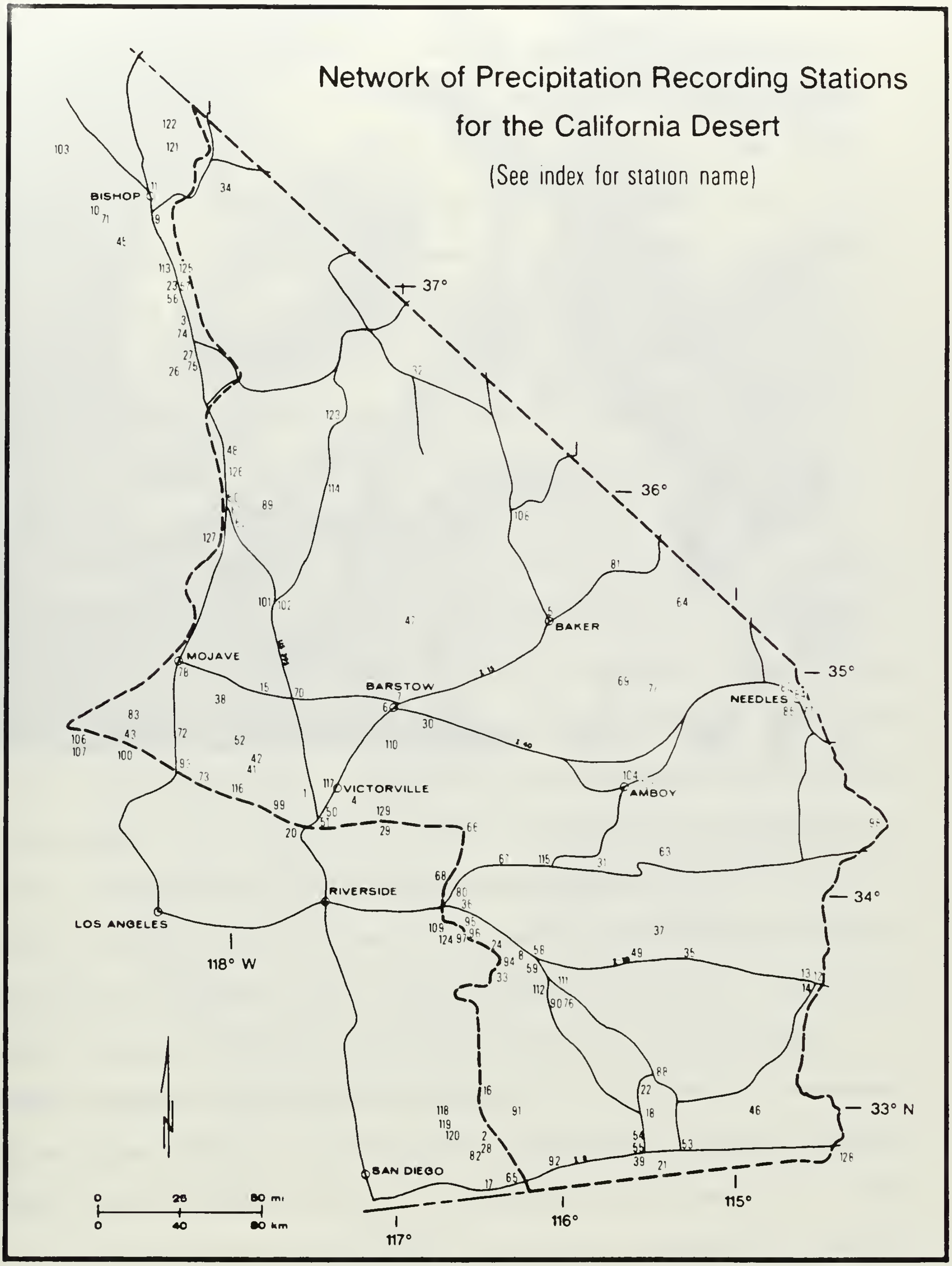
69. Kelso
70. Kramer Junction
71. Lake Sabrina (2)
72. Lancaster FSS (3)
73. Little Rock
74. Lone Pine
75. Lone Pine Cottonwood
76. Mecca Fire Station (66)
77. Mitchell Caverns (18)
78. Mojave (74)
79. Mono Lake
80. Morongo Valley
81. Mountain Pass
82. Mount Laguna
83. Munz Ranch
84. Needles
85. Needles County Yard
86. Needles Airport (86)
87. Needles Pumping Plant
88. Niland (35)
89. NWC China Lake (31)
90. Oasis
91. Ocotillo Wells (34)
92. Ocotillo 2 (6)
93. Palmdale (45)
94. Palm Desert
95. Palm Springs (81)
96. Palm Springs Fire Department
97. Palm Springs N SDOFFO
98. Parker Reservoir (43)
99. Phelan
100. Pine Canyon
101. Randsburg (39)
102. Randsburg F S
103. Rock Creek
104. Saltus No. 1
105. Saltus No. 2
106. Sandberg Patrol Station (49)
107. Sandburg Weather Bureau (44)
108. Shoshone (5)
109. Snow Creek Upper (57)
110. Stoddard Valley
111. Thermal Airport (27)
112. Thermal CDF Fire Station
113. Tinemaha Reservoir
114. Trona (57)
115. Twentynine Palms (42)
116. Valyermo (5)
117. Victorville Pump Plant (40)
118. Warner Springs - Hot Springs (
119. Warner Springs - CDF Fire Static
120. Warner Ranch House
121. White Mountain 1 (21)
122. White Mountain 2 (20)
123. Wildrose Ranger Station (11)

Addendum

124. San Jacinto Ranger Station
125. Los Angeles Aqueduct Intake
126. Little Lake
127. Freeman Station
128. Yuma, Arizona
129. Lucerne Valley

*NOTE:

Numbers to right of the station name in parantheses refer to years of record length, through 1976.



Network of Precipitation Recording Stations
for the California Desert
(See index for station name)
BISHOP
MOJAVE
BARSTOW
BAKER
NEEDLES
VICTORVILLE
AMBOY
RIVERSIDE
LOS ANGELES
SAN DIEGO
37°
36°
35°
34°
33° N
118° W
117°
116°
115°

Fig 8

Winter Cyclonic Activity (Frontal)

Cyclonic storms (counter-clockwise rotation) characteristically form off the coast of Alaska and are carried southward in the westerly wind belt. Because of the southward migration of the sub-tropical high pressure cell in the eastern Pacific Ocean, these cyclonic storms can affect California during the winter, or low sun, season. By the time they move into the desert, most moisture has already been deposited in the mountains. Still, some precipitation does fall in the CDCA and the desert sky is cloudy as these storms pass. Precipitation amounts from cyclonic storms generally decrease from north to south (although precipitation at a specific location is greatly controlled by exposure (windward or leeward) and elevation).

Figure 9 is a satellite image of a typical cyclonic storm. Because California and much of the CDCA are located south of the storm's center, dominant air flow into California is from the southwest rather than from the northwest. This means that warmer air (sub-tropical origin) moves on-shore into California as compared to the colder air from the northwest that moves on-shore into the Pacific Northwest. The snowline in the Sierra Nevada (a northwest-southeast trending white line) stands out dramatically in comparison with the snow-free areas surrounding the Sierra Nevada. Note the contrast between maritime locations (coast) and the rainshadow location of the CDCA. Low stratus clouds off-shore do not penetrate into the desert.

Figures 10-12 illustrate some conditions associated with cyclonic disturbances and the effect of the Sierra Nevada as an orographic barrier to cyclonic passage into the CDCA. Figure 10 is a Landsat image from 14 December 1972. It dramatically illustrates a Tule fog condition in the Great Central Valley of California, and how the Sierra Nevada preclude movement of fog into the desert. As previously noted, a similar situation develops with

Figure 9 shows a cyclonic storm moving onto the Pacific Northwest. As the cloud movement indicates (counter-clockwise rotation), the air flow into southern California is from the southwest. Thus, the air mass that typically affects southern California is characterized by warm, moist air. The colder air from the northwest affects northern California and the Pacific Northwest. The image was taken by the SMS-2 satellite in early May, 1975.

Fig 9

Figure 10 impressively illustrates the effectiveness of the Sierra Nevada as a barrier to storms and circulation from the west. The cloud and fog (Tule) over the Great Central Valley of California cannot move into the desert because of the presence of the Sierra Nevada. The rainshadow effect of the Sierra Nevada is also illustrated. Snow is found over much of the Sierra, but the eastern scarp is snow-free. As air moves downslope on the eastern side of the Sierra Nevada, compressional heating precludes significant precipitation.

Source: Landsat Image E-1144-18012-701

Date: 14 December 1972.

Fig 10

the movement of cyclonic storms from west to east in California: the majority of precipitation falls on the windward slopes of the Sierra Nevada, and by the time the storm moves into the CDCA, its moisture content has been greatly reduced, and downslope winds compress (and therefore heat) the air, further removing the air mass from its condensation temperature (dew point).

Figure 11 shows light snow cover associated with the passage of a cyclonic storm in California. Snow and cloud cover predominate in Owens Valley and on desert ranges, but most of the CDCA is snow-free. Mean daily temperatures for stations located in or near the area represented by Figure 11 on the date of the image, 14 January 1974, are given in Table 5.

Table 5

Station	Mean Daily Temperature (14 January, 1974)
Baker	46
Bishop	22
Deep Springs	24
Eagle Mountain	50
El Mirage	40
Haiwee	28
Independence	26
Mojave	46
Randsburg	40
Trona	45
White Mountain 2	21
Wildrose RS	35
Death Valley	50

Source: California Climate, 1974.
U.S. Department of Commerce

Of particular interest on Table 5 is the temperature difference of the lowest elevation stations (e.g., Bishop) found in Owens Valley as compared to the highest elevation station, White Mountain 2 (ca. 12,000 feet, 3,688m). In that there is little temperature difference, but a great elevational difference (nearly 8,000 feet, 2,438 m), indicates the severity of cold air

Figure 11 is a Landsat scene of a portion of the Mojave Desert and Basin and Range. The significance of this image is the area covered by snow and cloud cover. The Owens Valley, nearly to Indian Wells Valley, is covered by snow and clouds, as are the major mountain ranges. Note that the majority of area is snow-free. See text for temperatures for the date of the image.

Source: Landsat Image E-1540-17573-701
Date: 14 January 1974.

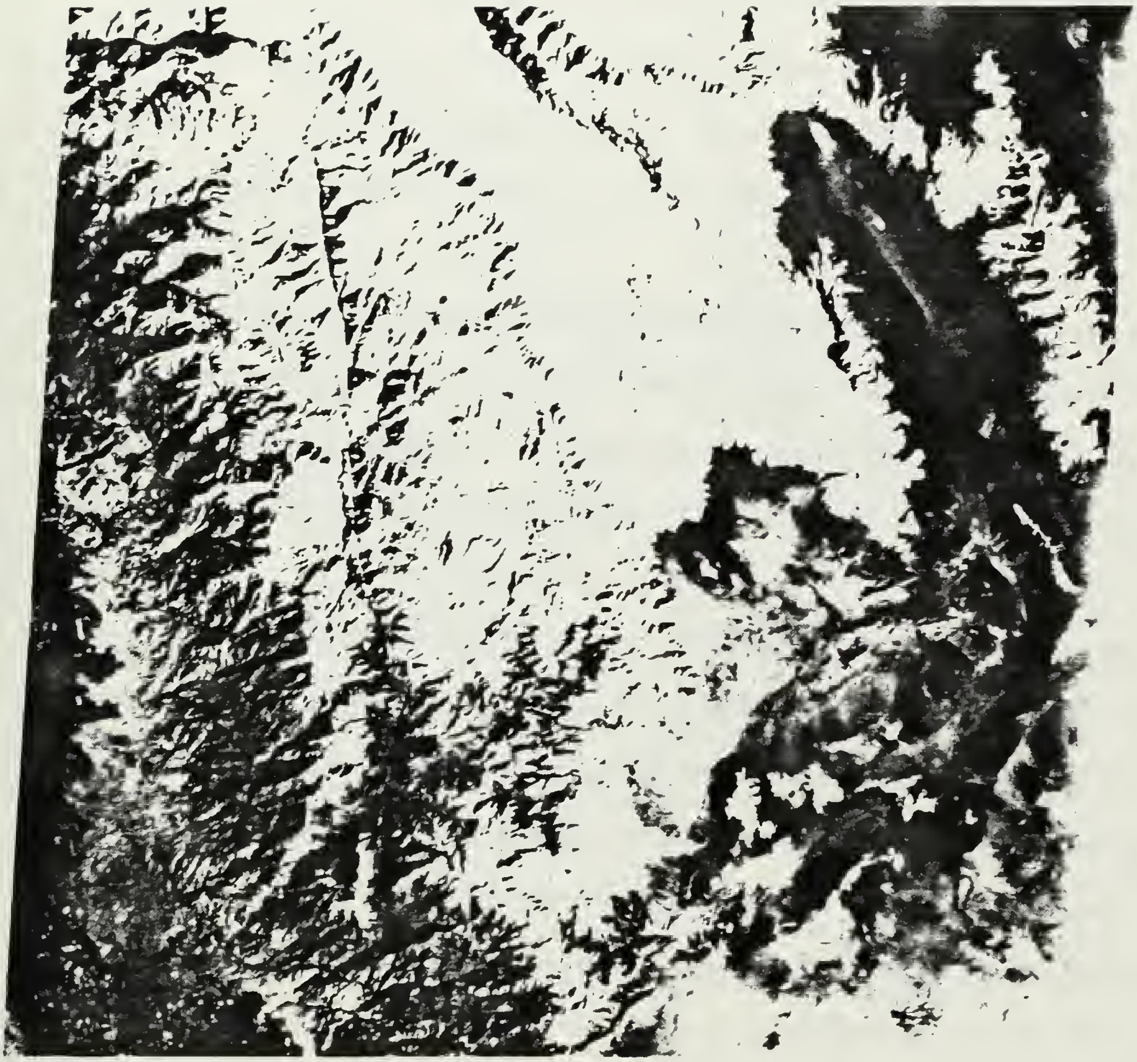


Fig 11

drainage in Owens Valley and the development of a shallow temperature inversion as a result of radiational cooling (temperature inversions were addressed in a previous section of this report). The warmer air temperatures recorded by stations located in the eastern and western portions of the Mojave Desert (e.g., Mojave, Eagle Mountain) are associated with a flow of warmer air from the south (Gulf).

Figure 12 shows residual cloud cover associated with the passage of a cyclonic storm in California. Commonly, these storms bring only gusty winds and cool daytime temperatures to the CDCA. Precipitation is seldom intense; lightly falling rain is the norm for most inhabited locations in the CDCA.

The percentage of annual precipitation falling during the six winter months progressively decreases from west to east across the CDCA. Cyclonic storms are less effective in the eastern and southern margins of the CDCA than they are in the western portions of the Mojave Desert or Basin and Range.

Figure 13 illustrates the general clustering of stations located in reasonably similar geographic areas of the CDCA as a function of the percentage of the annual precipitation falling during the six months of winter, October through March. The dashed lines surrounding the different stations have no statistical significance and are included for visualization purposes. As Figure 13 illustrates, the Mojave and Basin and Range areas generally have more than eighty percent of the annual precipitation total falling during the six winter months, while in the Coachella and Imperial Valleys the percentage drops off to about 60 to 75 percent. Stations in Arizona and Nevada show that the percentage of rainfall during winter drops to nearly fifty percent. Most of the Arizona and Nevada stations are located

Figure 12 is a Landsat scene of a portion of the eastern Mojave and the Basin and Range Province. The scene recorded residual clouds following the passage of a cyclonic storm in California. Little or no precipitation falls with a typical cyclonic storm, but gusty and high velocity winds generally follow the passage of one of these storms.

Source: Landsat Image E-1521-175222-702

Date: 26 December 1973.

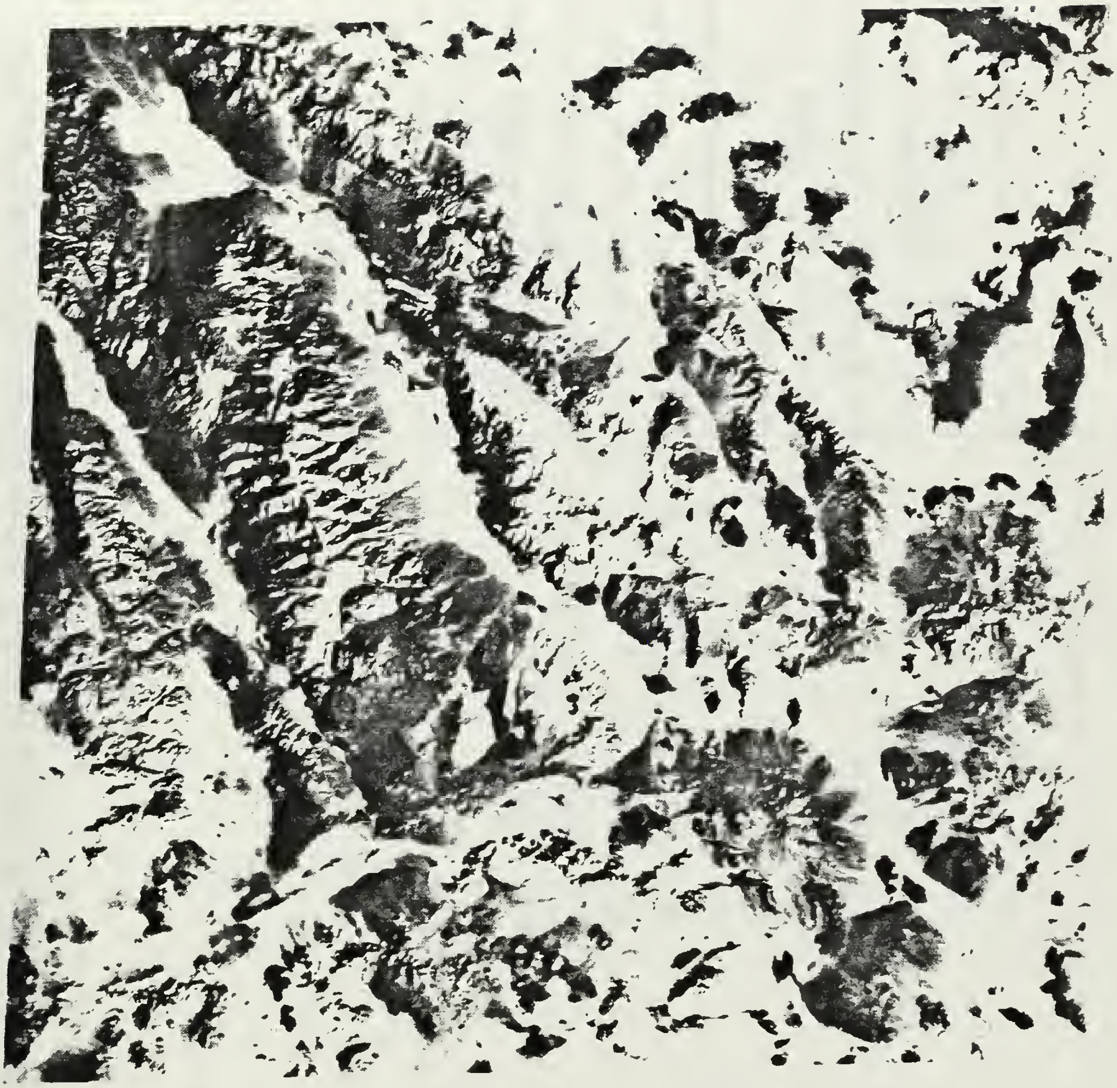


Fig 12

STATION INDEX

1. Big Pine
2. Bishop
3. Fairmont
4. Haiwee
5. Independence
6. Palmdale
7. Squirrel Inn
8. Trona
9. Valyermo
10. Blythe
11. Boulevard
12. Brawley
13. Death Valley
14. El Centro
15. Imperial
16. Indio
17. Parker
18. Yuma, AZ
19. Adaven, AZ
20. Caliente, AZ
21. Mina, AZ
22. Boulder City, NV
23. Las Vegas, NV

The stations represented on Figure 13 cluster according to winter precipitation characteristics. Most stations located in the Mojave-Basin and Range have the highest percentage of winter precipitation (frontal activity). (Essentially the western Mojave). The Coachella and Imperial Valleys, and Death Valley, receive less winter precipitation and more summer precipitation than the Mojave-Basin and Range stations. Moist tropical air from the Gulf of California and the Gulf of Mexico affect these locations, although not to the degree of stations located in western Arizona and southwestern Nevada. As one moves eastward across Arizona, summer precipitation becomes even more significant.

NOTE: There is no scale value for the X-axis.

Percent of Precipitation Falling During Six Winter Months
at Selected Desert Locations

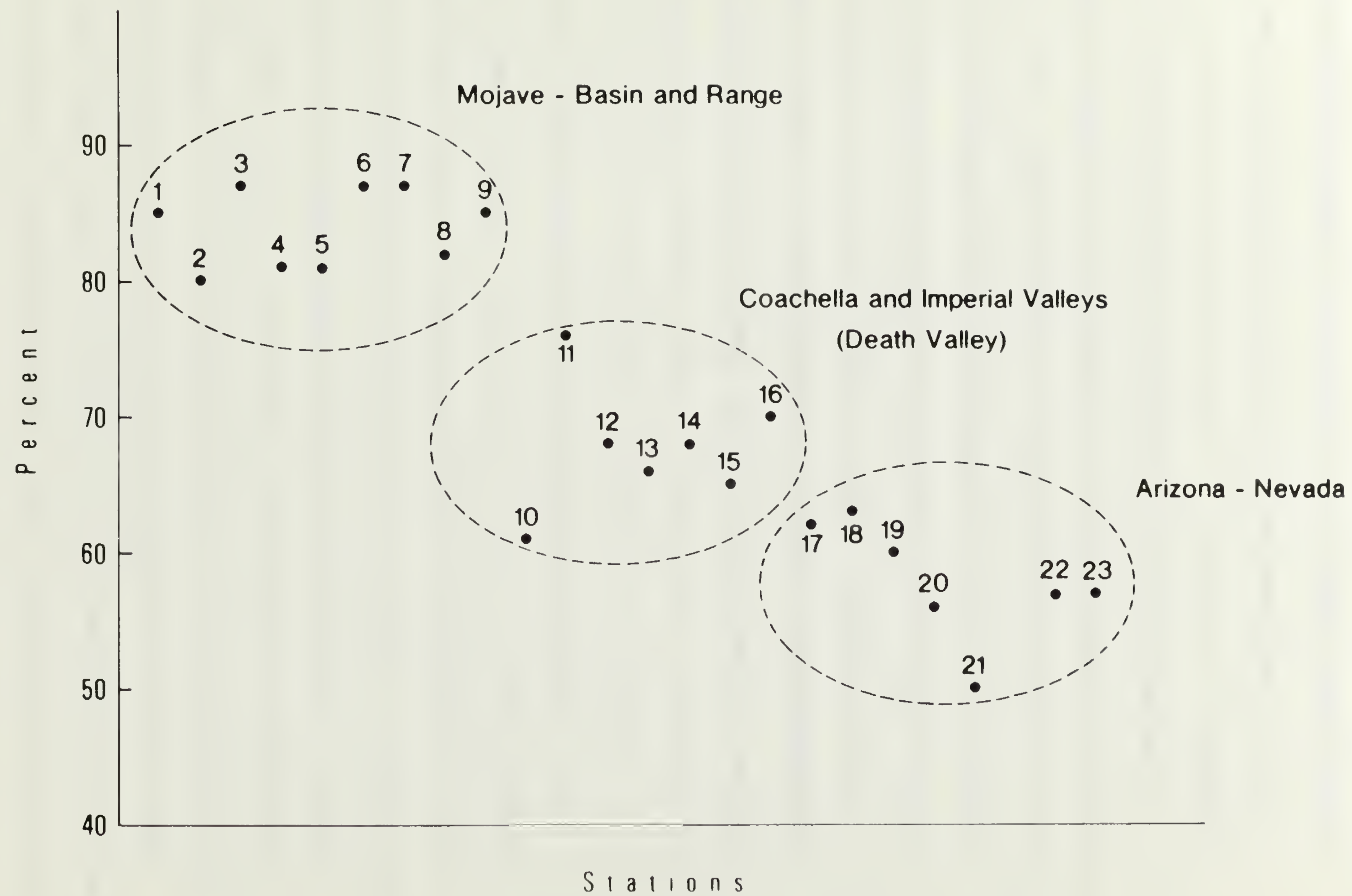


Fig 13

in the western part of each state; if one selected data from a central or eastern Arizona station, the percentage of winter precipitation would fall below that of summer. For example, at Tucson, in southeastern Arizona, forty-three percent of the annual precipitation falls during winter; the rainiest months are in July and August when intense summer thunderstorms develop.

Because of its low elevation and extreme isolation from moisture sources, Death Valley is included with the Coachella and Imperial Valleys. In fact, many stations located in the east Mojave have a strong summer precipitation tendency as compared to stations in the west Mojave. Thus, it is logical to separate stations located within the east Mojave from those located in the west Mojave. Movement of air from the Gulf of California and Mexico has a significant effect upon precipitation totals in the east Mojave, as the narrative on the second dominant circulation pattern describes

Summer Convectional Precipitation and Tropical Storms

The second circulation pattern, which actually consists of several sub-circulations, dominates the CDCA during the warm season, primarily from July through September. In essence, this pattern draws moisture-laden air, in varying degrees of intensity, from the south (Gulfs of California and Mexico). Resulting weather in portions of the CDCA is characterized by thunderstorms. As will be noted below, the summer conventional pattern does not extend over the entire CDCA with equal magnitude.

Because the largest percentage of insolation in the CDCA is devoted to sensible air heating, rather than evaporation, rising air currents (convection) near the ground surface result in establishemnt of a low level, or surface, low pressure system, one that persists over most of the CDCA throughout summer. Low pressure in the desert brings in moisture from the Gulf of California (as near surface flow) and enhances the advection of moisture from the Gulf of Mexico (Hales, 1974). Typically, the air is unstable and upon encountering topographic obstructions it rises and condenses, forming cumulus or cumulonimbus (thunderhead) clouds.

During summer, cyclonic storms (fronts) from the Pacific Northwest periodically move across the northern and central portions of the CDCA. These storms also draw moisture-laden air from the south. The CDCA topography dictates, to a large degree, that air must flow near the ground surface. Therefore, general predictions may be made as to what areas in the CDCA can expect to have the largest frequency of convectional storms.

Detailed analysis of weather satellite imagery and synoptic daily weather charts (surface and 500 millibar) for the summer of 1975 allowed for identification of four characteristic summer circulation sub-patterns over the CDCA:

1) air flow from the Gulf of California up the Colorado River Valley - a more common event than upper level flow from the Gulf of Mexico - into the east and central Mojave as a result of thermal low pressure formation in the desert (lack of substantial topographic obstructions allows for free air flow into the CDCA region east of Blythe.

2) air flow from the southwest (San Diego to Santa Barbara) to the northeast; precipitation on windward slopes of the mountains surrounding the CDCA results in a characteristically dry air mass.

3) air flow from northwest to southeast; often this circulation is associated with passage of a cyclonic (frontal) disturbance from the Pacific Northwest.

4) air flow from the northeast to the west-southwest across the CDCA, a circulation characterized by dry stable air.

Of the four summer circulation sub-patterns, the first type occurred most frequently and will be described below.

Influx of Tropical Air

During the time period examined, the thermal low pressure system centered upon the area of Devils Playground and extended to the southeast. Both intensity and extent of the thermal low pressure system varied over time. Although a number of weather types can be associated with this low pressure system one in particular appeared numerous times. Whenever the low pressure system exhibited intense cyclonic (counter-clockwise) flow, moisture would be drawn in from the Gulf area and interact with easterly air flow of the westerly wind belt. The result was widespread cloud buildup from the vicinity of Barstow to the southeast down the Colorado

River Valley. Almost all of the cloud buildup consisted of towering cumulus and cumulonimbus clouds. The majority of the weather stations (e.g., Las Vegas, Daggett, NWC China Lake, Needles) reported precipitation "in the distance" with the center of most intense precipitation focused on mountain ranges in the central and eastern Mojave. Figure 24 in the Wind section of the report includes a map of macro-wind flow over the CDCA and identifies the general area of most intense summer convectional precipitation.

Occurrence of summer precipitation in the CDCA has extreme significance in terms of plant distributions, and a distinction should be made between the western Mojave and eastern Mojave, the later of which receives a larger percentage of its annual precipitation total in summer.

For simplicity, one can use the range of contours from 1200-1500 feet (366-457m) elevation to separate the western and eastern Mojave. The contours extend along the eastern and northern flanks of Joshua Tree National Monument to east of Twentynine Palms, then north to the vicinity of Ludlow. From Ludlow, a line drawn to the Mojave River wash, near Baker, and north along the western border of Death Valley would approximate the separation of the two desert regions. Although it is only an approximation, this line separates the Mojave Desert quite satisfactorily. One reason explaining the greater summer precipitation concentration east of the above defined line is that as maritime tropical air moves into the Colorado River Valley area and Salton Trough, it diverges both northward over the eastern and central portions of Joshua Tree National Monument and westward through Rice Valley where few topographic obstructions are encountered. More westward air movement is precluded by prevailing westerly circulation dominant over the western Mojave.

Table 6 clearly illustrates the larger percentage of summer precipitation in the eastern portion of the Mojave and in the Colorado Desert as contrasted to the western Mojave. Compared to Figure 13, which presents the percentage of winter precipitation, Table 6 gives the percentage of annual precipitation that occurs during the three primary months of summer.

TABLE 6

Station	Percentage of annual precipitation occurring in July, August and September.
Barstow	23%
Blythe	36
Daggett	34
Eagle Mountain	36
Haiwee (W)	12
Hayfield	19
Inyokern (W)	12
Iron Mountain	29
Needles	36
Palmdale (W)	5
Palm Springs	12
Parker	28
Randsburg (W)	9
Sandberg (W)	2
Twentynine Palms	47
Victorville (W)	12
Thermal	20
Indio	24
Brawley	29

Note: The (W) identifies stations in the western Mojave.

The relatively low value for Palm Springs is explained by its physical isolation at the base of the San Jacinto Mountains.

Tropical Storms

A less frequent type of summer storm, but very significant because of its environmental effects, develops in the CDCA when tropical storms (hurricanes) form off the west coast of Baja California. The effects of a tropical storm vary in accordance with how far north and east they move. On rare occasions, they actually move onto the California coast (1976, 1977) with severe flash flooding common in the Salton Trough and Colorado River Valley. Figure 14 is a graph of precipitation amounts falling during the summer months of 1951 when a tropical storm formed off the Baja California coast. As the graph clearly shows, stations in the Salton Trough and along the Colorado River Valley experienced the largest precipitation amounts. Although the graph displays data for all three summer months, almost all of the precipitation fell in a period of several days during the height of the storm. Stations in the western and northern Mojave had only slight precipitation amounts, or none at all.

Figure 15 is a satellite image of a tropical storm that brings intense precipitation to the Salton Trough and Colorado River Valley. As these storms rotate (counter-clockwise), moisture is drawn inland, and as the unstable air mass moves across the heated land surface, it rises and towering cumulus clouds develop. As indicated earlier, if mountains are encountered in the air flow path, even more intense thunderstorms can develop.

Because of the shorter duration and greater intensity of summer convectional storms, as compared to winter cyclonic storms, less infiltration and greater surface runoff results. Figure 16 shows typical surface runoff (sheet wash) from a recent summer thunderstorm in the east Mojave.

One of the most severe tropical storms to hit the southern and eastern

STATION INDEX

1.	Lancaster	11.	Eagle Mountain
2.	Palmdale	12.	Borrego Springs
3.	Backus Ranch	13.	Iron Mountain
4.	Inyokern	14.	Borrego Desert
5.	Daggett	15.	El Centro
6.	Thermal	16.	Brawley
7.	Lucerne Valley	17.	Needles
8.	Kee Ranch	18.	Parker
9.	Twentynine Palms	19.	Blythe
10.	Hayfield		

The stations represented on Figure 14 show the significance of the influx of moist tropical air from the Gulf of California or the Gulf of Mexico on precipitation regimes in the California Desert. The primary location for significant storm development during the summer is along the Colorado River into the eastern California Desert.

The majority of the precipitation totals represented fell in a period of days, not months as the graph would indicate. The precipitation comes as intense precipitation; flash flooding and heavy surface runoff are commonly associated with these storms.

Rainfall Falling During July, August, and September, 1951

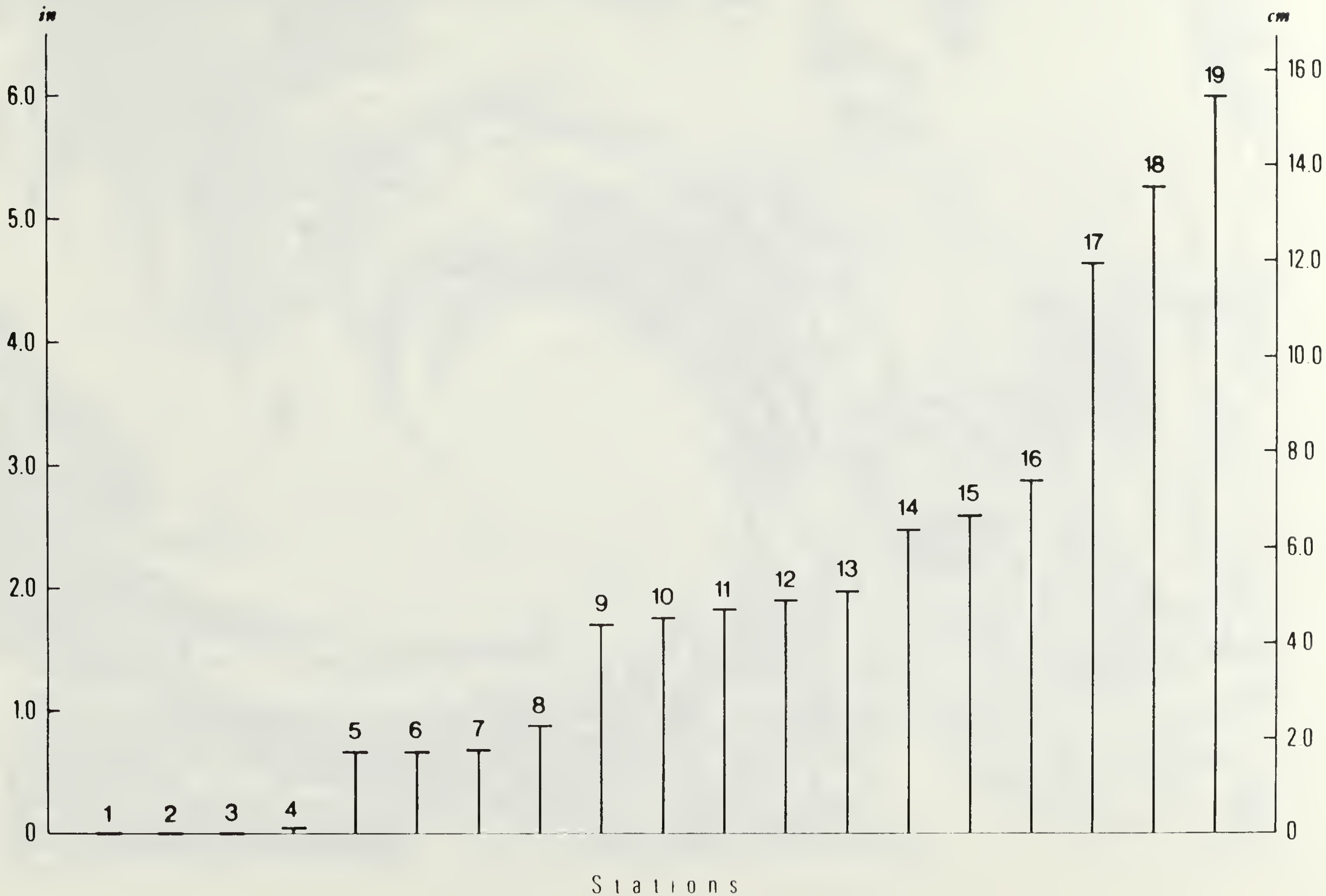


Fig 14

The image in Figure 15 was taken by the Navy's Meteorological Satellite on 5 October 1977. The tropical storm shown is located off the southwest coast of Baja California. Note how moisture can be drawn up the Salton Trough and Colorado River Valley.

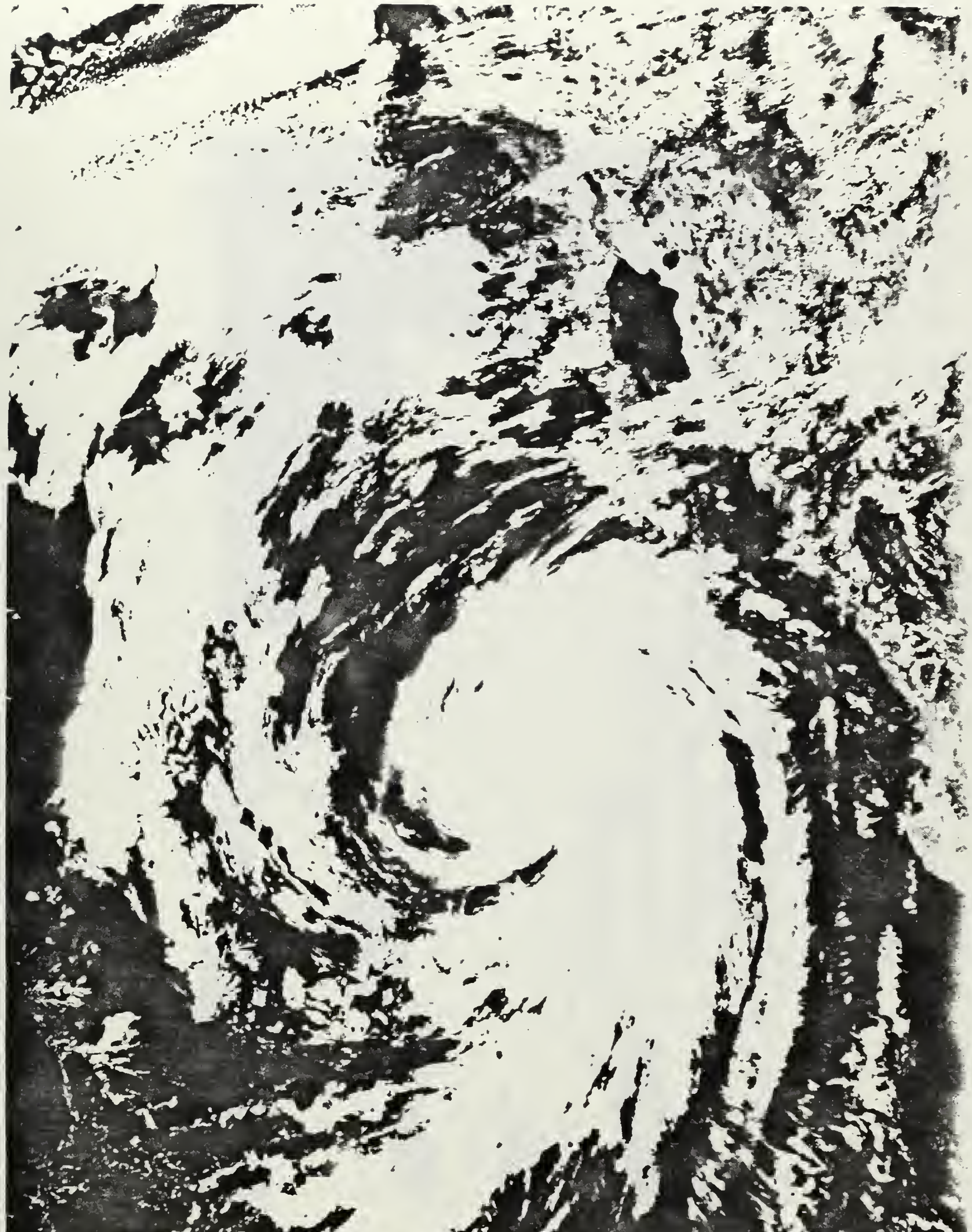


Fig 15

Figure 16 shows the intensity of surface runoff (sheet wash) that occurs during an intense summer thunderstorm in the CDCA. Although the storm may last in one spot for only a few minutes, the landscape alteration that is possible is significant. Flash floods are common with these synoptic conditions. The photograph was taken on Kelbaker Road near the I-40 off-ramp in September 1975. During this same storm, standing waves in excess of four feet (1.2 m) were noted in major washes.

Fig 16

portions of the CDCA in recent years was hurricane Kathleen (1976). Kathleen was the first tropical storm to actually strike California in 37 years. The storm passed through California on 9-10 September 1976, bringing widespread destruction to many parts of San Diego, Imperial, Riverside and San Bernardino counties. An estimated 8-10 inches (20-25 cm) of rain fell in about eight hours along the crest of the Laguna Mountains, eighty miles (129 km) east of San Diego. Because of the rocky and sparsely vegetated surfaces along the western side of the Salton Trough, almost all of the rainfall runoff became torrential sheets of water.

Although rarely do tropical storms actually penetrate into California, effects of these storms, even while off the coast of Baja California, are commonly seen in the CDCA. An interesting description of Kathleen and associated damage is given by Larson (n.d.).

The speed with which summer thunderstorms can develop is illustrated in Figures 17-18. The two images were taken the same day (25 July 1975), one in mid-morning and the other mid-afternoon. On that date, intense precipitation and severe flash flooding occurred in Arizona. According to Weather Bureau publications (Storm Data) on the day preceding these two images, the most violent thunderstorm, with winds in excess of 60 mph (96 kph), in over a decade struck Tucson.

The Landsat image of 26 August 1972, Figure 19, shows cloud development associated with thunderstorm activity. On this date, of sixty-nine stations in the California Desert, fourteen (20%) reported precipitation. On August 27, twenty-two stations (32%) reported precipitation. For the entire month of August, Lucerne Valley recorded 2.26 inches (5.7 cm) of rainfall, with a total of 2.10 inches (5.3 cm) falling on 12 August alone.

Figures 17 and 18 show the speed with which summer thunderstorms can develop. The two images were sensed approximately six hours apart. The first image shows cloud development in the morning, while the second shows cloud development by mid-afternoon. On this date severe flooding occurred in Arizona (see text). Almost all of the CDCA was free of cloud, although the Sierra Nevada had a nearly continuous band of cloud by late afternoon.

Source: SMS-2 Weather Satellite

Date: 25 July 1975.

Fig 17

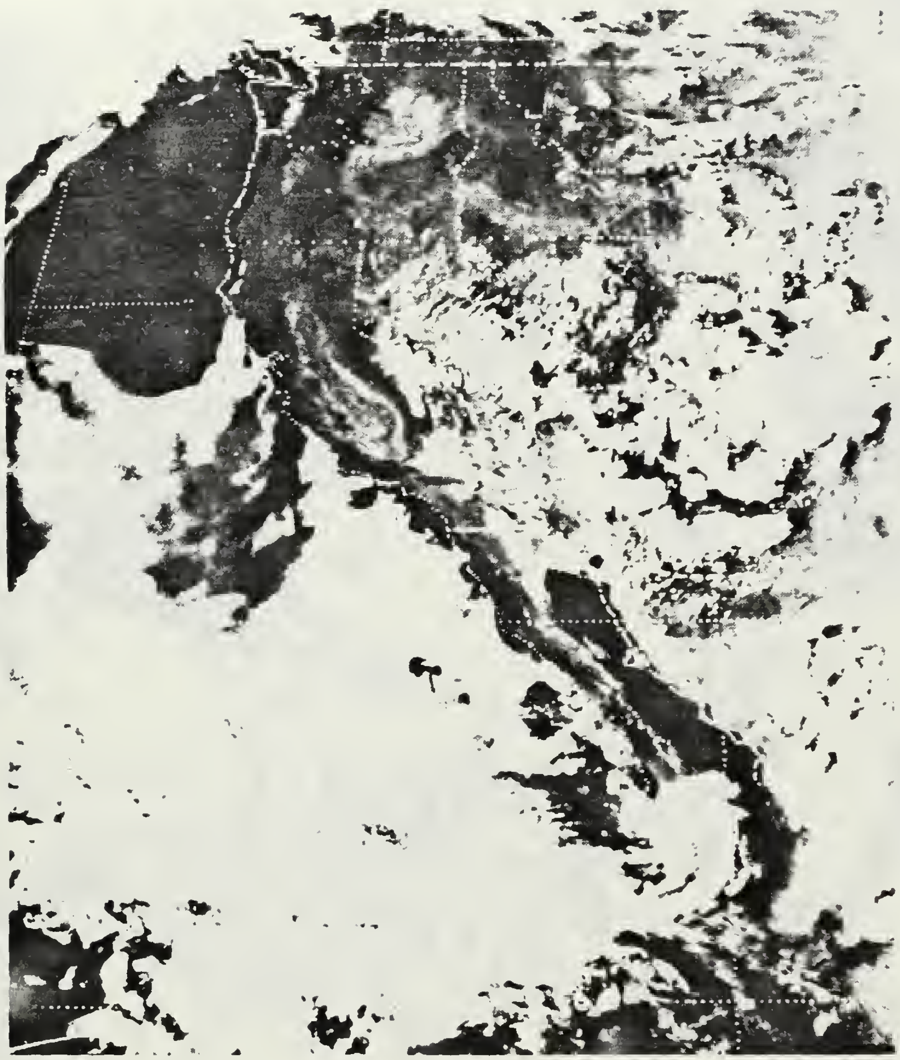


Fig 18

Figure 19 illustrates the cloud development associated with thunderstorm formation. Only two large cumulus clouds have developed by the time of the image (approximately 0930 local time). Because Landsat images the same place only once every 18 days, and then during the morning, the probability of a fly-over during a period of extensive thunderstorm development is low.

The area imaged on Figure 19 focuses on Bristol Lake. The Colorado River and Needles appear in the upper right corner of the image.

Source: Landsat image 1034-17493-71

Date: 26 August 1972.

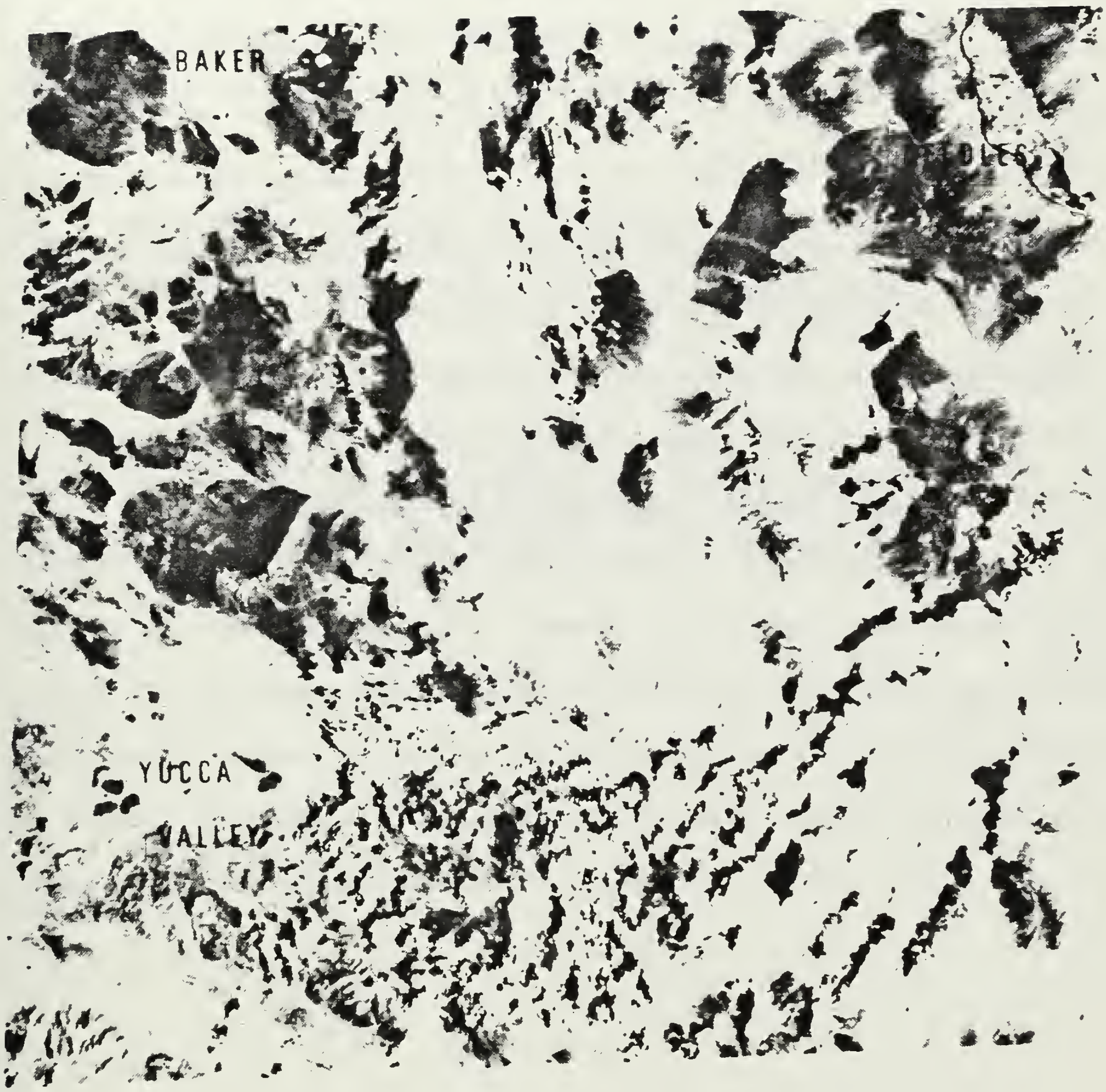


Fig 19

When unstable air rises against the east side of the southern Sierra Nevada, not a common event, severe and destructive flooding can occur. A prime location for flash flooding during these periods is the area around Red Rock Canyon. Historical files maintained by the Department of Water and Power, City of Los Angeles, indicate that resulting storms can be most violent. A Department of Water and Power field logbook recorded the following description of a flash flood in the western Mojave on 23 August 1961:

> lots of water splashed over the top of Jawbone and Pine tree syphons (did not flow over). Also Cameron Canyon washed out. The valley between Cantil and California City was water everywhere.

Also taken from the files was a citation from 21 September 1939:

> run-off from storm station 2143 (?) to sta 2480 but greatest run-off was between 2165 and 2392 and 40 where dirt has been washed away and roads damaged. Roads washed out at stations 2328 and 70 . . . .

Summary

Although summer precipitation can be caused by several types of general circulation patterns, two are most significant. The most common occurrence of summer precipitation is a result of moisture-laden air moving into the CDCA from the Gulf of California. Topographic obstructions cause cloud buildup and the resulting rain can vary from extremely localized intense showers, leading to flash flood conditions, to more widespread light showers. The eastern Mojave is more affected by this circulation pattern than the western Mojave. Another important form of precipitation, although extremely rare, comes when tropical storms forming off the coast of Baja California move into the CDCA. Often the heavy rain may last for days with widespread destruction evident, especially in the southern desert.

Summer precipitation for the entire CDCA is rare. However, the east Mojave and Colorado River Valley characteristically receive a large percentage of their annual precipitation during summer. Summer precipitation is important for at least two reasons. Firstly, the relative amount of precipitation falling in the summer months helps determine both regional and localized plant distributions. Secondly, summer precipitation is often intense and can cause great damage to man-made construction, as well as present grave danger to desert inhabitants and visitors.

Precipitation Effectiveness

The effectiveness of precipitation to flora is a complex function of several variables. Foremost among these variables are temperature, seasonality of precipitation, intensity of precipitation, and exposure. The last variable, exposure, is important in that south facing surfaces in the CDCA (sunny side) receive more insolation than the more shady north facing surfaces. The effect of exposure is to increase or decrease evaporation rates from the soil surface. As evaporation from the soil is enhanced, the vegetative luxuriance of vegetative cover is reduced. North facing slopes have relatively higher evaporation rates, too, as wind speed is directly proportional to evaporation rates.

Intensity of precipitation has already been noted in a previous section In those areas of the CDCA that have a high frequency of summer convectional storms, the percentage of precipitation that results in surface runoff is large. Because of the high intensity and short duration of these summer storms, much of the moisture cannot infiltrate into the subsoil. Precipitation from the normally more gentle cyclonic storms of winter, dominant in the western and central Mojave, is more likely to infiltrate into the soil, resulting in less surface runoff. Flash floods are less likely in the central and western Mojave than in the eastern Mojave and Salton Trough.

Most indices of precipitation effectiveness focus on temperature under the reasonable assumption that temperature is a primary forcing function of evaporation rates (insolation data give more accurate calculations of evaporation, but paucity of insolation data preclude its use in most cases). As temperature increases, evaporation rates increase and vice versa. Thus, higher elevations have less thermal stress placed upon them and precipitatio effectiveness is greater than at lower elevations where evaporation is enhan

That fact alone explains, in part, the greater biomass production found at higher elevations. Higher elevations also receive considerably more precipitation than lower elevations.

The annual range of temperature as well as the mean annual temperature (Table 2) are both important factors. Evaporation increases with temperature; also the amount of evaporation will depend, in part, upon the annual range of temperature. The annual range of temperature is especially important with respect to the season of maximum precipitation concentration. Because precipitation is primarily concentrated in the cooler half of the year in the western and central Mojave, evaporation rates are less than if precipitation maximum occurred during the warm half of the year. Thus, if two areas receive the same annual total of precipitation, a relatively greater amount of precipitation can be available for plant growth in the area that has a cool season concentration of precipitation. Of course, many floral species require summer precipitation, and that fact alone may be the primary reason explaining the presence of certain floral species in the eastern Mojave as compared to wet-winter areas of the western and central Mojave.

Throughout the CDCA, actual evaporation rates, as measured by standard weather bureau evaporation pans, are large. According to published data, evaporation rates exceed 100 inches (254 cm) in Death Valley. In Death Valley, the potential evaporation exceeds the precipitation by a factor of about 40. In areas of the CDCA, evaporation rates exceed the amount of precipitation.

Snow

Snow does not immediately come to one's mind when discussing precipitation characteristics of the California Desert, but it is an integral part of the CDCA climate. In most instances, snow does not last for extended periods of time, with the exception of high desert ranges (White, Inyo, Panamint, Providence, Kingston Mountains) where the snow can, and usually does, last throughout the winter season.

Snow can occur anywhere, with the possible exception of the lower elevations of the Salton Trough. Snow fell at Furnace Creek in Death Valley on New Year's Day, 1973. On the average, snow falls 1.6 days per year at NWC China Lake. Snow falls even at Needles, along the Colorado River, where, on the average, only 0.2 day per year has snow fall in excess of 1.5 inches (3.8 cm).

At higher elevations (4,000-7,000', 1219-2134m) in the CDCA, snow is both more common and persistent. In many of these higher elevations, snow drifts can be substantial. Drifts develop because consistent winds pile newly falled snow against an obstruction, or move snow into an area protected from the main airstream. Lack of extensive and tall vegetative cover contributes to the formation of snow drifts.

Robert Ausmus (see letter in Appendix) reported that in the East Mojave, in the vicinity of Cima-Essex, during the winters of 1937-38 and 1948-49, snow on level ground completely covered four and five foot (1.2-1.5m) fences. Obviously, these winters were not typical, but they do indicate that moderately high portions of the CDCA can experience severe winter conditions. Mr. Ausmus noted that the severe winter of 1949 was accompanied by strong winds resulting in snow drifts twenty feet (6.1m) deep. In 1949, the Southcott family of Gold Valley could not get to Cima for their mail, they

had to change their postal address to Essex, for a period of six weeks because of deep snow (Ausmus, personal communication). At that time, Black Canyon was completely filled with snow.

Every five or six years, less severe storms bring 20 inches (51 cm) of snow and usually each winter brings some snow to the East Mojave.

Mr. Ausmus's letter effectively describes snow occurrence above the 4,000 foot (1,219m) contour in the CDCA. To be sure, in the northern portions of the CDCA (e.g., Eureka Valley and environs) snow is even more important (Figure 1).

Precipitation Variability - Trends

Arid regions typically have high precipitation variability. Equal or near-equal precipitation amounts from year to year seldom occur. Degree of precipitation variability at stations within the CDCA result as a function of the particular site and situation of each station. The CDCA contains diverse terrain that has associated with it, complex precipitation regimes. Station elevations range from below sea-level to greater than 12,000 feet (3658 m) in desert mountains; in addition large regional areas such as the East Mojave have moderately high elevations (4,000-5,000'; 1,219-1,524 m).

Death Valley probably has one of the most variable precipitation regimes of any station within the CDCA. Since records were first taken in Death Valley, 1911 through 1977, Death Valley recorded at least one year without any precipitation (1929). In 1949, only 0.31 inch (0.78 cm) of precipitation was recorded, and during the period 1911-1977, there were seven years in which less than one inch (2.54 cm) was measured. In absolute values, the variability of precipitation at Death Valley may not be great (zero to five inches, zero to 12.7 cm), but in terms of percent changes, the degree of variability is great.

For stations within the CDCA, an indication of precipitation variability can be gained by examination of Table 7, which presents calculated seasonal and annual values of the coefficient of variation for precipitation. The greater the value, the greater is the relative variation of precipitation. The advantage of using the coefficient of variation is that it allows for comparison between stations, or areas, inorder to determine where the greatest variations occur. A disadvantage of the measure is that in arid regions the mean precipitation value is small, and because the coefficient of variation

Table 7

COEFFICIENT OF VARIATION VALUES OF PRECIPITATION

FOR SELECTED STATIONS IN THE CDCA

	Annual Precipitation		Coefficient of Variation		
			summer	winter	annual
Palmdale	6.99"	(17.8 cm)	136%	61%	46%
Palm Springs	4.51	(11.5 cm)	110	60	59
Parker	4.37	(11.1 cm)	91	72	49
Randsberg	5.05	(12.8 cm)	104	65	55
Sandberg	14.81	(37.6 cm)	166	70	43
Thermal	2.13	(5.4 cm)	108	92	58
Twentynine Palms	3.35	(8.5 cm)	88	74	53
Victorville	4.38	(11.1 cm)	175	67	52
Morongo Valley	8.41	(21.4 cm)	117	76	54
Eagle Mtn.	2.50	(6.4 cm)	85	89	46
Haiwee	6.08	(15.4 cm)	97	71	48
Hayfield	2.55	(6.5 cm)	110	77	47
Indio	2.54	(6.5 cm)	116	90	63

is dependent upon the mean precipitation value, the calculated coefficient of variation may be questioned in terms of real world applications. The reason the coefficient of variation has been questioned is that the value is calculated by taking the long-term standard deviation of precipitation and dividing it by the mean precipitation value for the same time period. When mean precipitation values are small, the coefficient of variation value is large. At times, the value is so large that it seems meaningless. Statisticians often consider a value of 1.00 (or 100%) to be statistically invalid (because the range of variation is greater than the mean value). However, in desert environments a value in excess of 100% is not uncommon, especially if data are calculated on only a monthly or seasonal basis. Even on an annual basis, coefficient of variation values are large, as Table 7 indicates. If only one year during the time period examined had an unusually large amount of precipitation (or if one year had no precipitation), then the calculated coefficient of variation would be greatly exaggerated because the mean precipitation value for the time period would be so significantly altered. In environments where the mean precipitation value is large, variation in precipitation amounts is less significant in the calculation of the variability coefficient.

Even with the possible statistical drawback of this measure, the coefficient of variation does give some relative information regarding precipitation variability within the CDCA to the resource planner.

Within the CDCA the trend in precipitation appears to be downward. That is, over the period of record examined (1950-1975), there has been a general decrease in the amount of precipitation received at each station. (James Huning, unpublished manuscript). The trend was calculated according to regression analysis. The only station in, or near, the CDCA that exhibite

an increase in precipitation over the period was Bishop, at least for the stations analyzed (which was a function of the available record length).

In all liklihood, the tendency toward a precipitation decrease resulted from a change in storm track patterns during winter. Storm tracks were located in a more northerly location, thus explaining, in part, Bishop's slight increase. Whether the shift of the storm tracks represents a significant climatic change or only a perturbation in the overall picture of atmospheric circulation is not known at the present time. During the past few years, many stations in the CDCA have recorded an increase in precipitation rather than increased winter storm activity, however.

The most important ramification of a long-term decreasing trend is that many springs and water holes are drying. According to Charles Douglas, Research Biologist with the National Park Service and Biologist at University of Nevada, Las Vegas, of the nearly fifty springs and water holes in Joshua Tree National Monument, only twelve were still effectively flowing. (personal communication). Assuming this trend is representative of the CDCA in general, the long-term effects upon flora and fauna could be substantial (as noted, however, the past few years have brought about an increase in annual precipitation). To be sure, the effects of increased ground water pumping would have a significant effect upon the persistence of streams and water holes. An analysis of well records within the CDCA should shed valuable information on this subject.

WIND IN THE DESERT

The CDCA is a relatively windy area because the lack of significant vegetative cover presents little friction between the ground-surface interface. In addition, high solar input results in convective overturning of the low lying air strata which in turn results in gusty winds during the afternoon. This convective overturning is most easily evidenced by the formation of dust devils in many areas of the CDCA, especially between two different types of ground surface: between the desert surface and a highway; between a playa surface and the partially vegetated surroundings of a playa. The pressure difference that develops results in the formation of a small vortex (rotating air) that can persist for several minutes. The afternoon winds and dust devils are capable of moving fine dust particles and if their velocity is great enough, sand particles. During evening and night, these winds dissipate as radiational cooling leads to the formation of a chilled air layer near the ground surface and cessation of convective overturning.

Throughout most of the CDCA, wind direction is predominately from the southwest or west, although during winter or summer dominant winds may be from northerly or southerly quadrants. Because the CDCA is located in the westerly wind belt of the global atmospheric circulation, the dominant winds are from the west.

In the western Mojave, air moves into the desert area from the coastal lowland of Los Angeles and from the southern portion of the San Joaquin Valley. In the former case, air moves into the desert through Soledad Canyon and through Cajon Pass. In both areas high velocity winds are not uncommon whenever a large pressure gradient separating the coastal basin from the desert exists. If the air in the coastal area has a large concentration of

pollutants or has a large moisture content, these characteristics will be advected into the desert, often resulting in a substantial decrease in desert visibility. Strong air flow is very common from the coastal lowland and inland basins into the northwestern portion of the Coachella Valley (Palm Springs vicinity) for the same reason. In the case of air flow from the San Joaquin Valley to the western Mojave, air moves through Tehachapi Pass and through Walker Pass.

Wind velocities throughout the CDCA are quite variable, but physical principles may be applied for a better understanding of why and where high winds occur. Because air is a fluid, it corresponds to the topography through which it is flowing. Of greatest significance is that air flow will follow Bernoulli's principle. That is, a given mass of moving air will be forced to increase its velocity as it passes through a canyon or through a gap in the mountains in order for the entire volume of air to pass by in a given amount of time. As an example, if air is moving along from the north in the Mojave, it will eventually encounter the San Bernardino and San Gabriel Mountains. Because very little air will pass over the mountains, most of it will flow laterally along the front of the mountains until it reaches a passage through the mountains: Cajon Pass. Travel through Cajon Pass can be hazardous because of high wind velocity if a large volume of air is being forced through the pass. In this particular case, the basics of a Santa Ana wind have been described.

Santa Ana winds are common to the desert, but do not have a high frequency of occurrence. Figure 20 is a Landsat image of a strong Santa Ana wind on 1 January 1973. Of particular interest are the numerous dust plumes apparent on the image. Areas of origin of the dust plumes warrant examination in that preliminary field reconnaissance has shown that most sites from

The Landsat image shown in Figure 20 captured the strongest Santa Ana wind of 1973. The image was taken 1 January 1973. On the image numerous dust plumes are clearly seen. The sites from where the dust originates have all been disturbed by some activity (off-road vehicle activity, grazing, cleared for development, etc..). The more impressive plumes nearly go over the San Gabriel Mountains (elevations greater than 10,000 feet (3048m)). The wind velocity is greatest where the air is forced to funnel between topographic features. The wind velocity is greatest in an area like Cajon Pass where a great mass of air is forced through a relatively small constriction (Bernoulli's principle).

Source: Landsat Image
E - 1162 - 18013 - 701

Date: 1 January 1973

Fig 20

A classic example of why high velocity winds develop in the environs of Windy Point, near Palm Springs, shows in Figure 21. The image was taken by a U-2 aircraft on 2 March 1973 (Mission 73-030). The cloud pattern represents the marine layer while the clear area represents desert air. An indication of air movement from the marine layer into the desert clearly shows. The clouds are dissipating as they move into the more dry desert air. A strong pressure gradient exists from the coast to the desert. Because of the constriction formed by the mountains, the velocity of the air must increase here. Windy Point is open to the full force of moving air. Under typical late spring and early summer conditions, two contrasting air masses may be found in the coastal plain and the desert.

73030

2 March 1973

Image #8190

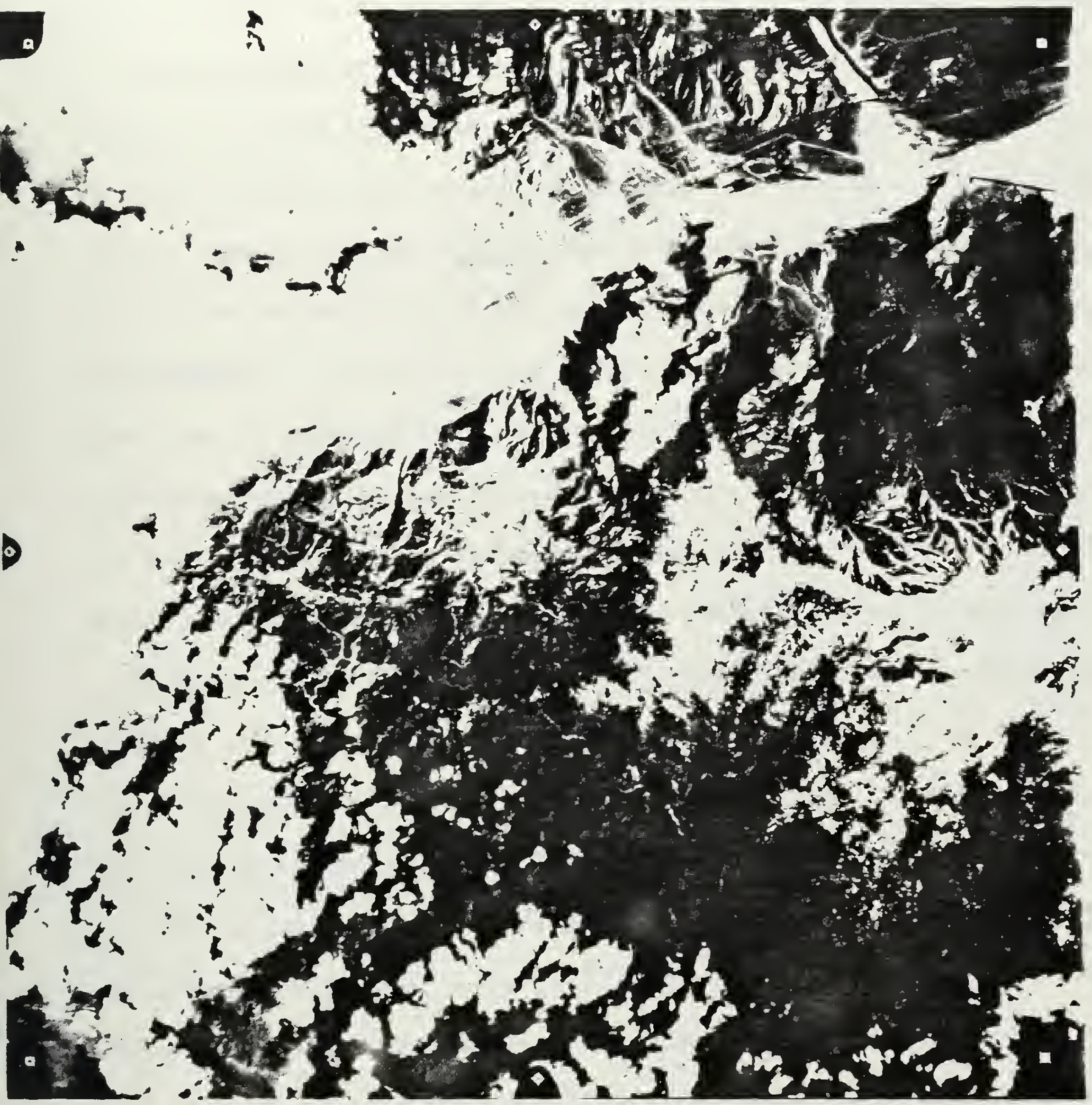


Fig 21

where dust is originating have been disturbed. Disturbance has been caused by a variety of activities: off-road vehicle activity; grazing; land prepared for future development, and the enhanced drying of Owens Lake because of diversion of water by the City of Los Angeles. The advection flow of air through canyons or mountain passes can be substantial. A classic example is the northwestern portion of the Coachella Valley, near Windy Point. Figure 21 illustrates the typical situation. A mass of moist cloudy maritime air covers the coastal lowland and into the Perris Plain. The air moves rapidly through Banning Pass into the Coachella Valley. One can easily visualize the movement of air into the dryer and lower air pressure desert environment. Late spring and early summer are the most common months for the type of synoptic picture presented in Figure 21 to form. Strong winds can generate during or after the passage of a cyclonic disturbance in winter as well. Considerable movement of sand occurs with these winds. The railroad tracks north of Palm Springs are protected from blowing sand and migrating dunes by a long row of trees which serve to trap the moving sand and disrupt the air stream.

Because there is such a paucity of wind data for the desert, one can use surrogate environmental information to determine dominate wind direction. An example of the use of surrogate information for determining wind direction is given in Figure 22. Figure 22 shows the environs of Bristol Dry Lake, Amboy Crater, and the National Chloride Company's facility on Bristol Lake. The lack of sand accumulation leeward of Amboy Crater indicates the dominate westerly wind flow. All other areas of the lava flow have been covered with sand or fine soil particles. The only area free of deposition is that area directly leeward of Amboy Crater (indicated by the black lineament).

Long-term wind data for stations located in or near the CDCA are graphically displayed in Figures 23 a-f. These wind roses were constructed by

An indication of prevailing wind direction is noted in Figure 22 by the lack of sand accumulation on the basaltic material downwind of Amboy Crater. In this part of the desert, the most prevailing wind direction is from the west.

In many areas of the desert, one must draw upon observational or visual data such as this U-2 image in order to determine, or approximate, wind direction.

The facility imaged on the photograph is the National Chloride Company on Bristol Lake, south of Interstate 40.

Source: Nasa Mission 73-030 (image 8302), U-2 platform
Date: 2 March 1973

Fig 22

taking the mean annual wind speed from each direction on a 16-point compass and multiplying each wind speed by the frequency of occurrence (percentage of time) the wind came from each direction (the station model, Figure 23a, presents the legend-direction, speed/distance scale - common to all graphs). Thus, a victor is drawn for each of 16 compass points. This type of representation gives more attention to high wind velocities even though they may occur only a small percentage of time. A more useable portrayal of persistence and intensity of wind is given. Periods of calm are noted on each rose by the percent value given below the station name.

The topographic location of each station significantly determines the wind direction, as would be expected. Bishop, located in the northern part of Owens Valley, has a dominant north and south wind flow. NWC China Lake has a strong southwest wind component, while Edwards Air Force Base (AFB) has a dominant westerly flow. George AFB has an interesting wind rose in that a strong southerly wind flow persists. The southerly flow at George AFB results from air moving up and through Cajon Pass into the desert.

A classic westerly wind flow is represented by the wind rose for Daggett. Here westerly and near-westerly wind flow dominate (see Figure 22 for a surrogate determination of westerly wind direction in the general area of Daggett and along Interstate 40).

Data for El Centro and Yuma portray wind flow for the southern part of the CDCA. Perhaps surprisingly, the wind flow at El Centro is also predominately westerly, but by the time one moves to Yuma, AZ, the flow is dominated by air movement from the southeast and north. A wind rose of Nellis AFB, near Las Vegas, NV, is given for comparative purposes.

All speed and frequency data for stations located in the CDCA are given in Appendix C; several stations not graphed are included although record lengths for them are very short.

The two circulation patterns dominant over the bulk of the CDCA, southerly and westerly flow, are mapped on Figure 24, which also outlines the area in the CDCA that experiences most frequent summer convectional precipitation. As the figure shows, movement of the southerly air more westward is precluded by the general westerly circulation common over the CDCA's latitude. Topography enhances the summer convectional storm development in the area outlined on Figure 24.

Seasonal wind flow is represented by Figure 23f which presents three monthly wind roses for George AFB. As the figure indicates spring is the windiest month in the desert.

WIND ROSES

The wind roses given in Figure 23 a-f all have a common legend, given in Figure 23a. Note that the vectors represent the mean annual wind speed multiplied by the percentage of time that wind was from each of the sixteen point directions. A second scale, representing total annual distance, is also given. Several monthly wind roses are presented for George Air Force Base. Late winter and spring are characteristically the windiest times in the desert, the last three wind roses, Figure 23f, present monthly wind data for January, July and April at George AFB.

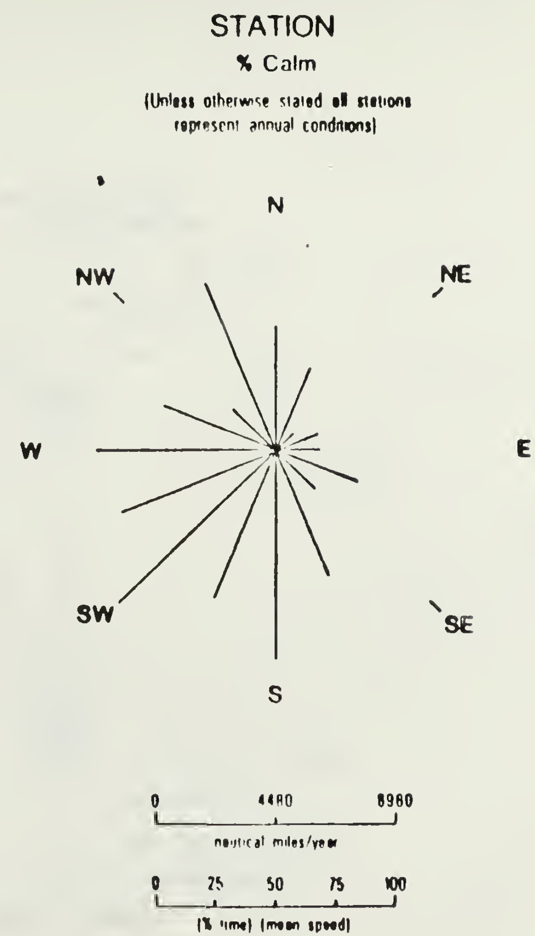
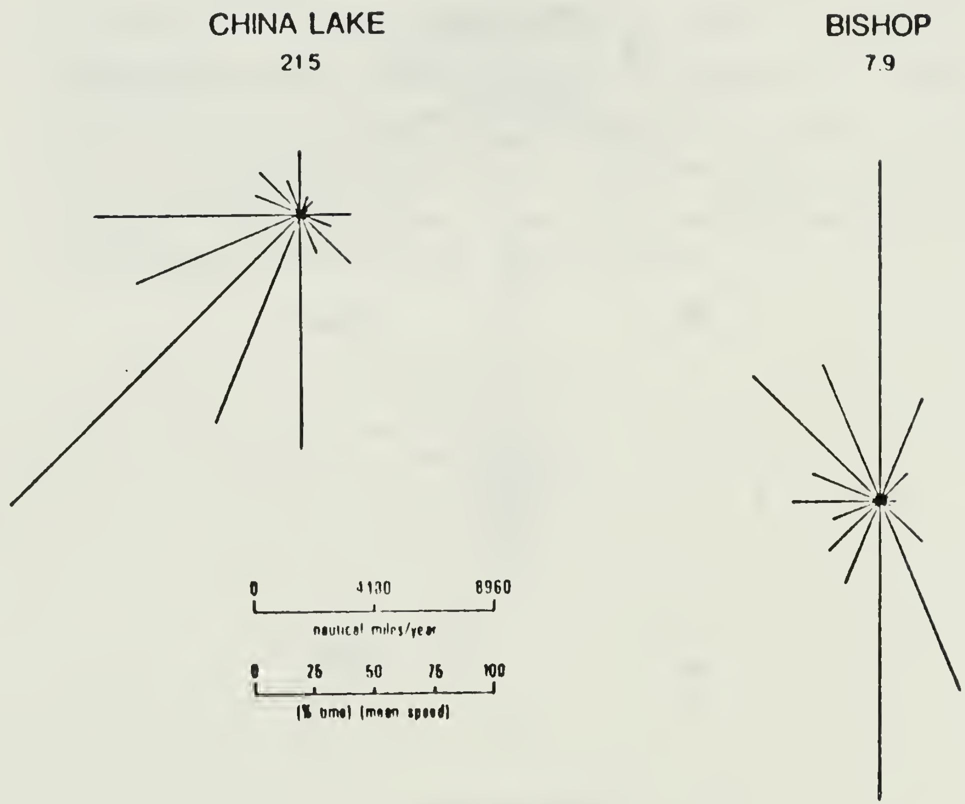
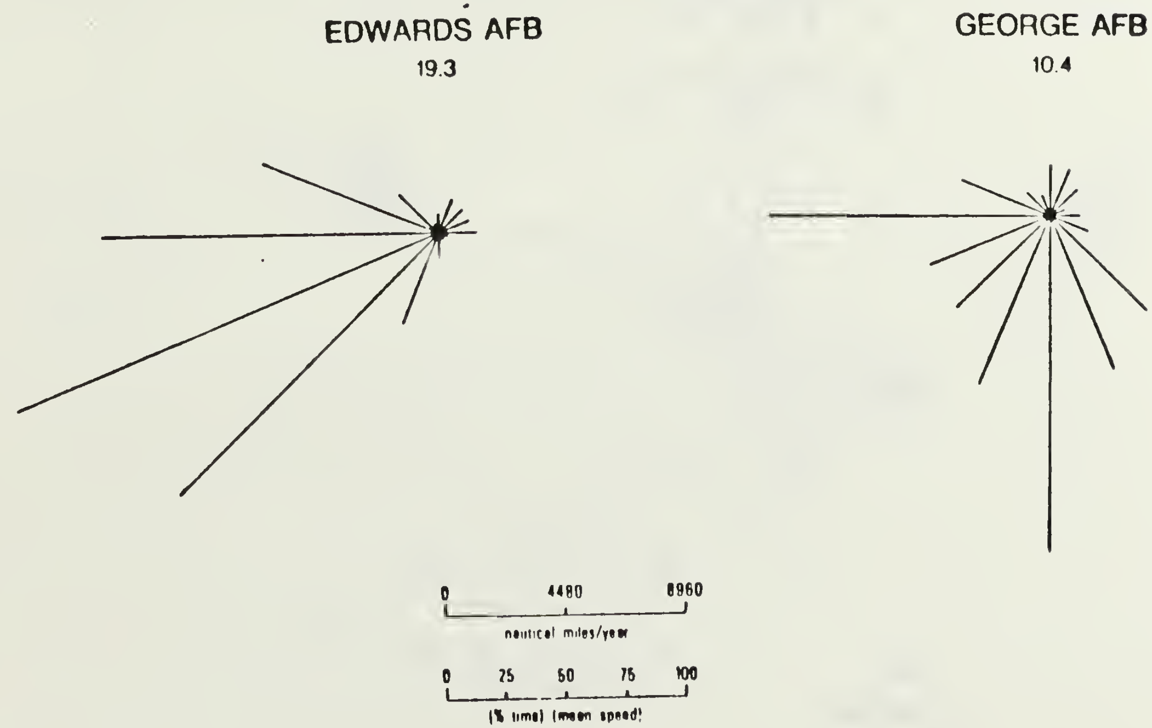

STATION
% Calm
(Unless otherwise stated all stations
represent annual conditions)
N
NE
E
SE
S
SW
W
NW
0
4480
8960
nautical miles/year
0
25
50
75
100
(% time) (mean speed)

Fig 23a


CHINA LAKE
21.5
BISHOP
7.9
0
4130
8960
nautical miles/year
0
25
50
75
100
(% time) (mean speed)

23b

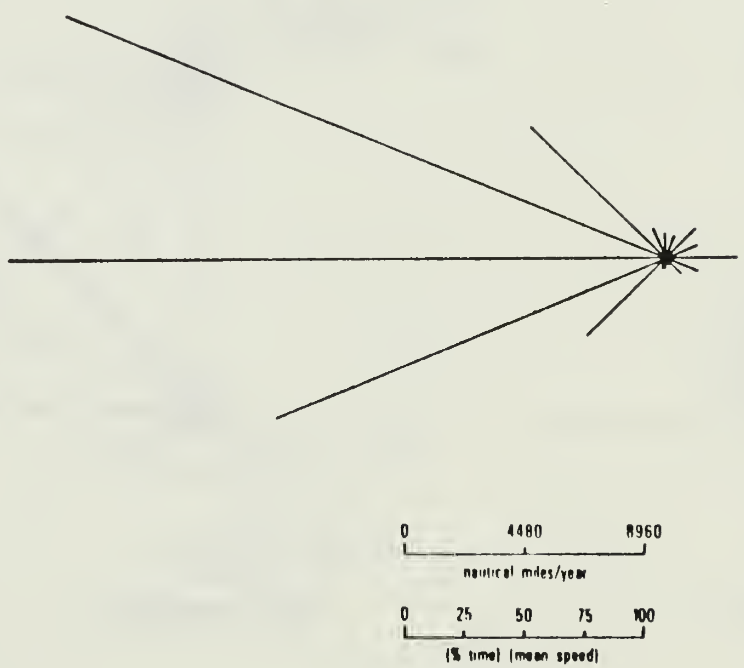


EDWARDS AFB
19.3
GEORGE AFB
10.4
0
4480
8960
nautical miles/year
0
25
50
75
100
(% time) (mean speed)

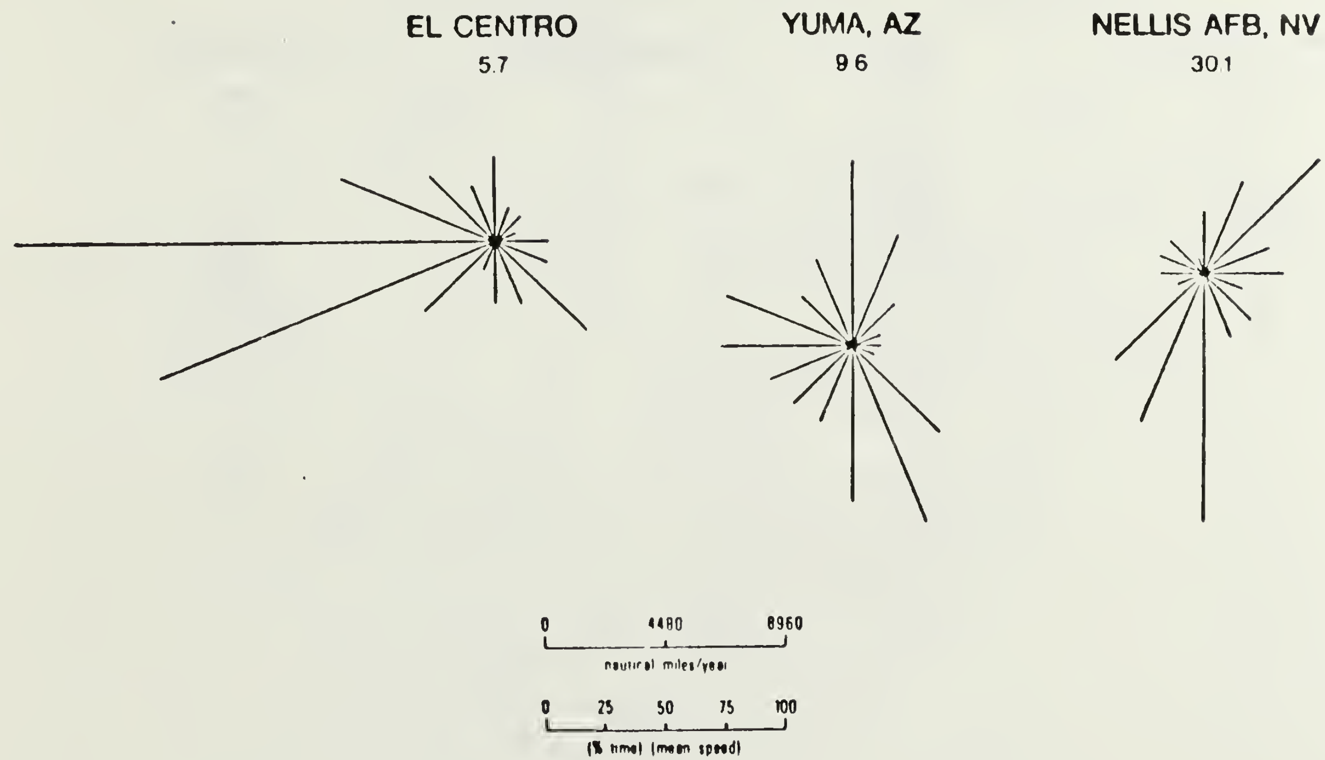
23c

DAGGETT

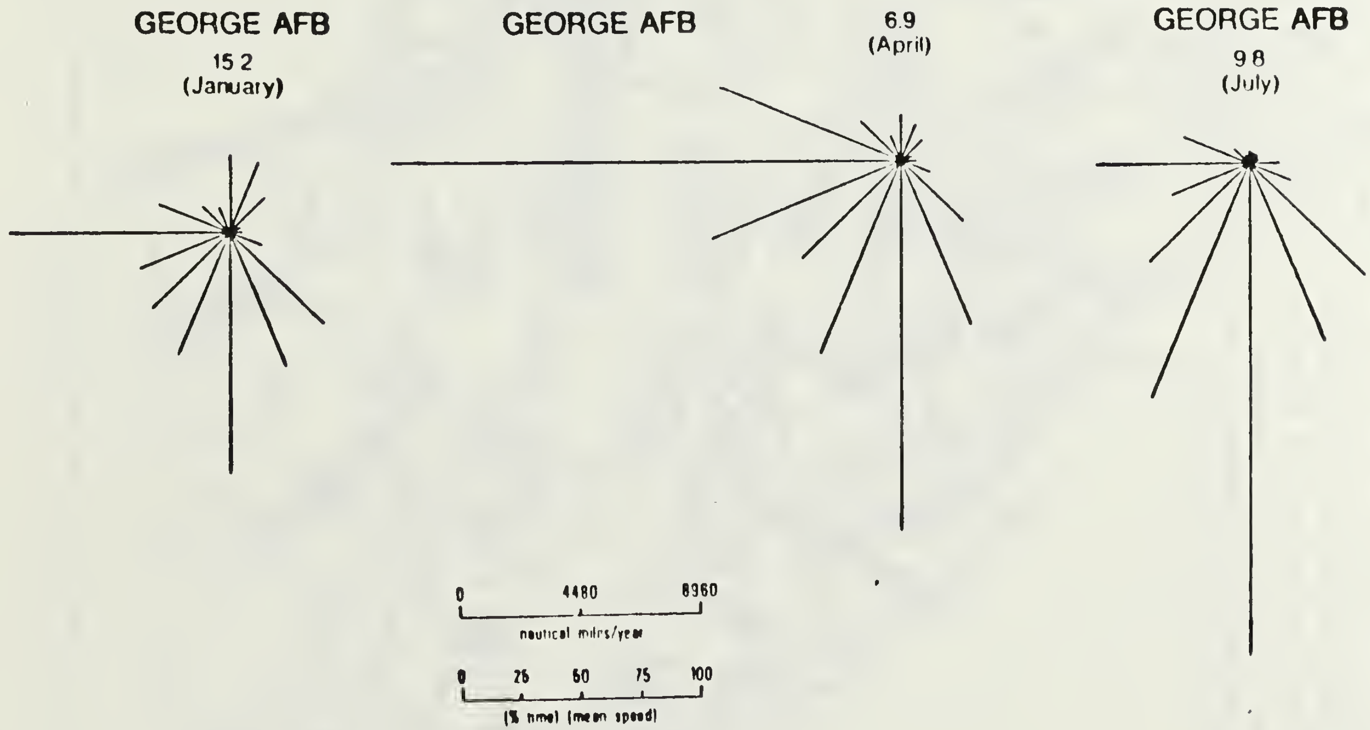
11.8



23d


EL CENTRO
5.7
YUMA, AZ
9 6
NELLIS AFB, NV
30.1
0
4480
8960
nautical miles/year
0
25
50
75
100
(% time) (mean speed)

2 3e


GEORGE AFB
15.2
(January)
GEORGE AFB
6.9
(April)
GEORGE AFB
9.8
(July)
0
4480
8960
nautical miles/year
0
25
50
75
100
(% time) (mean speed)

231

The Landsat photo mosaic of the California Desert, Figure 24, includes arrows that represent the direction of large-scale air flow over the CDCA. Note the two dominant air movements from the south and west. Where these two air flows converge is found the greatest concentration of summer convectional precipitation (identified on Figure 24).

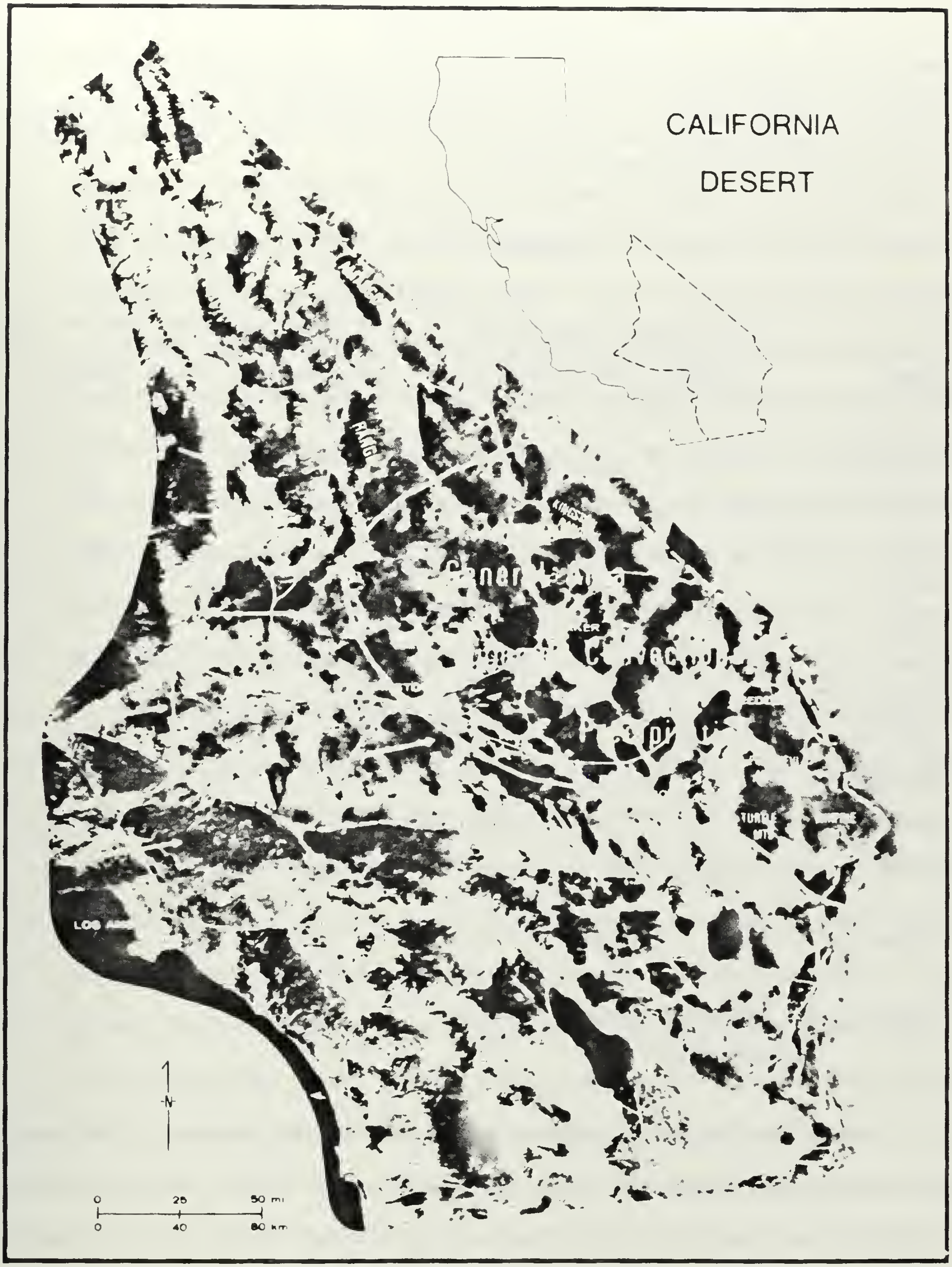


Fig 24

For NWC China Lake, data in Table 8 give the average number of days per month and year with peak wind gusts greater than 40 mph (64 kph) and the average number of days per month and year with surface wind equal to or greater than 15 mph (24 kph).

TABLE 8

Month	Days with Peak Gusts [40mph or more (64kph)]	Days with average surface wind equal to or greater than 15mph (24kph)
January	3	2
February	3	3
March	5	5
April	5	6
May	4	5
June	3	3
July	1	2
August	1	1
September	1	2
October	1	2
November	1	2
December	2	2
Annual:	30	35

Source: NWC Climatic Summary 1946-76
January, 1977.

These data confirm that spring is the windiest season in the desert, both in terms of peak gustiness and average wind speed. Of less significance in the desert is the occurrence of the dust devil, a very common occurrence in summer, discussed earlier.

PLANT-ENVIRONMENTAL RELATIONSHIPS

Physical Setting

The Mojave Desert is complex and varied, with important contrasts between north and south, between west and east, and between lowland and mountain. It is physically diverse; complex in geology, lithology, structure, and physiographic units; edaphic and vegetational differences are present; and it is climatically varied. Many dynamic geomorphological processes are currently sculpturing and modifying a wide assemblage of landforms derived from igneous, sedimentary and metamorphic rocks embracing almost the total range of geological age. For example, early pre-Cambrian crystalline metamorphic gneisses and schists, and igneous granitic rocks 1800 million years old, in the Black Mountains tower abruptly above young fanglomerates and recently formed and forming colluvial talus cones, alluvial fans, and sedimentary salt crusts (from capillary movement of water by evaporation in the Death Valley depression). Older volcanic lavas occur in many areas as well as very recent flows, cinder cones, tumuli (Owens Valley), maar, basaltic cinder cones (Ubehebe) and obsidian and pumice cones and domes (Coso Range) and the extensive and complex forms of the Amboy-Pisgah volcanic fields. Also widely present, and indicative of the structural, lithological and geomorphic diversity are young alluvials, extensive bajadas of old fanglomerates with desert varnish crusts dissected by arroyos and contemporary desert washes depositing new differently colored gravels, clay floored playas, saline crusts, saline lakes, seasonally snow-covered mountains, extensive plains, areas of variable form sand dunes, steeply tilted and block faulted ranges of complexly folded, faulted and intrusive structure, and relict geomorphic forms of sedimentary deposits of saline, lacustrine, silt and clay beds and fanglomerates of the more pluvial Plio-Pleistocene epochs.

In broad overall terms, the climate of the Mojave Desert is harsh, arid, and irregular with extremes of temperature and precipitation. Disregarding the local, seasonal and annual variability (Table 7) inherent in any hot arid environment, regional patterns of longer term differences in patterns of temperature range, seasonal incidence of precipitation, patterns of seasonal storm tracks and occurrence and frequency of temperature inversions (Figure 4) can be broadly recognized, or at least inferred. These influence ecological distribution patterns.

Despite the hardiness of the desert plants, i.e., their physiological tolerance of and their morphological adaptation (xeromorphy) to the harsh desert environment, the Mojave Desert is a fragile, sensitive, variable habitat for biota. Irregular habitat extremes are probably equally as important, and in some instances, possibly more significant, as regulators of vegetation patterns in the Mojave Desert than long-term climatic "average" conditions. The harsh climatic environment imposes important restrictions upon biota and stamps an unmistakable mould. Thus plant cover is sparse, plants are xeromorphs - either drought tolerant or drought adapted perennials - or drought avoiders (annuals, or more strictly, ephemerals). A wide range of morphological adaptations (leaf and stem, and root) to reduce moisture losses by transpiration, to store water, to optimise soil moisture uptake as well as physiological adaptations in photosynthetic process, characterize these desert plants. One or more of the following methods to reduce water loss are common: small leaves, inrolled, waxy coating, hairy surfaces, stomata reduced on under surface only, light colored, succulence deciduousness, phyllodes, and aphylly (stem succulence). Within this general mould, important modifications are manifested by the geomorphic, edaphic, and local climatic variety resulting from aspect; elevation, and temperature

inversion present within areas.

Preliminary field investigations -- although hampered by one of the more extreme wet and cloudy seasons that make up the "average" of desert climate -- suggest that broad patterns of vegetation can be equated with several environmental parameters: climate, geomorphic units, soil moisture, soil texture and soil salinity. Most of these are observations rather than fully tested conclusions.

The controlling or limiting factor for phraetophytes is a simple one -- available ground water. There is very distinct and abrupt zonation of communities with virtually no ecotones present. These are discussed later.

The role of climatic, geomorphic and edaphic environmental parameters in the distribution of xerophyte communities is more complex.

Climatic Parameters

Cresote bush (Larrea tridentata) is a common species forming both pure and mixed communities on gravel fans. Its altitudinal limit is about 4000 feet (1,219 m). Above this level it is replaced by sage brush communities that characterize the cooler northern mountain and basin areas. Is this upper limit simply a function of critical cool temperature? Is it orographic, i.e., simply elevation controlled? Or is this altitudinal limit a role of the elevation and frequency of zone of inversion layers present in many of the major structural valleys of the Mojave Desert? Is the critical temperature frequency an inversion induced one, rather than a simple function of temperature cooling with elevation? Temperature cooling with altitude shows a close correspondence with the 1200 foot (366 m) contour and the limit of Palo Verde and Ironwood in the southern and eastern parts of the Mojave Desert. Neither species can tolerate long periods of prolonged freeze. Other old established "temperature controlled" plant

distributions are the Saguaro in the warmer Sonoran zone and Joshua Tree in the cooler Mojave zone. These may be more specifically edaphically influenced.

With Joshua Tree (Yucca brevifolia) distribution, the presence of silts with a high moisture status, possibly from perched water table or from basaltic aquifers and soils from nutrient rich basalt lava parent rocks, could explain the presence of these plants in the Lee Flat area on the western side of the Panamint Valley at an elevation of 5,500 feet (1,676 m) and their absence at similar elevations on the eastern side of the Valley (supporting only sage brush). Both areas experience similar temperature and precipitation regimes.

Cresote bush is notably absent from steep short fans facing the south or when backed by western facing mountains. This can be interpreted as being too hot for this species. Thus, for a plant that appears so widespread throughout the Mojave Desert and that appears to be a very hardy xerophyte, it may be a relatively mesic one, being intolerant of cool temperatures above 4000 feet (1,219 m) elevation and of very hot conditions associated with aspects where late afternoon insolation reaches high peak values.

Annuals, or better termed ephemerals (as growth of these is more nearly at a five-year average occurrence than annually), are very sensitive indicators of climatic conditions, most notably of precipitation. However, use of this indicator quality is relatively impracticable. Areas covered by these plants in good growing seasons can be recognized on satellite imagery, but these plants can only be identified in the field. Furthermore, they can be recognized confidently only by a very small number of specialized taxonomists. Each species is unique with dependence upon seasonal moisture

i.e., winter or summer rain and whether the previous season was favorable for growth. Generally, a summer flush of ephemerals is not usually followed by a winter flush of growth even if optimum climatic conditions occur. This may result from problems of nutrient depletion with the previous season's growth or with minor allelopathy (toxicity from the preceding ephemerals).

The infrequency and localized occurrence of ephemeral growth can augment information about perennial plant-climate interrelationships but cannot be used as a major input in any modelling of plant environment parameters.

Geomorphic Parameters

Several geomorphic factors appear to exert significant influence upon plant community distributions in the Mojave Desert. Slope, degree of exposure to sun and wind, nature of the materials and age of surface are important. Steep weathered rock slopes are usually devoid of plant cover, steep fans have little or few widely spaced plants present. Gentle slopes of the extensive fanglomerates support relatively dense communities.

The long gentle northern and eastern slopes such as Emigrant Wash and Hanaupah fan from the Panamint Range into Death Valley are generally better vegetated than those facing to the south and west or those exposed to channelled winds.

The fanglomerates of the extensive bajadas are formed of coarse gravels near the flanks of the mountains, grading into finer materials -- silts and clays where they merge into playas. Typically, creosote bush is present over most of the fan gravels except at the lowest levels occupied by saltbush. Saltbush (Atriplex spp.) occur as mixed communities with creosote bush near the playa edge of the fans and burroweed (Franseria dumosa) replaces creosote bush at the heads of the fans.

The extent of desert varnish on the surfaces of the fanglomerates exerts an important role in plant distribution. Fan surfaces and gravel terraces with desert varnish support no plant growth. Deflation of fine materials plus the varnished pebbles form a surface unsuited to plant establishment. However, wherever these surfaces are broken with gullying and recent desert wash courses these tongues of newer materials support vegetation. This pattern is most prominent in the long fanglomerates extending eastwards from the Argus Range almost across the entire width of the Panamint Range into Death Valley. The old desert varnish surface interfluves are bare but often quite shallow rills, washes and valleys support chiefly creosote bush. Basic geomorphic-plant relationships are diagrammed in Figures 25 and 26 .

Soil texture, soil moisture and salinity play important roles in influencing plant distributions in the Mojave Desert. Mention has been made already of the possible role of soil texture, soil moisture and soil nutrients in the distribution of Joshua Tree. The replacement of the "lower Sonoran zone" xerophytes (creosote bush, desert holly, cattle spinach, and burroweed) at 4000 foot elevation with "upper Sonoran shrub zone" sagebrush species may be a reflection that the gravel fans do not generally extend beyond this. Higher basins tend to be of finer silts with different water holding capacity than the fanglomerates. This, either independently or in conjunction with climatic factors, or cooler temperatures alone providing higher precipitation effectiveness, could provide the reason for a quite dramatic plant community change. These are all avenues for future investigation.

Both soil texture and soil salinity influence the distribution of creosote bush, desert holly (Atriplex hymenelytra) and cattle spinach (A. polycarpa). Creosote bush requires non-saline soils but can grow on very stony

On fanglomerates, the older surfaces have desert varnish and little, if any, vegetation growth, while the eroded surfaces or new fan alluvials support vegetation.

Cross - Section Across Fanglomerate

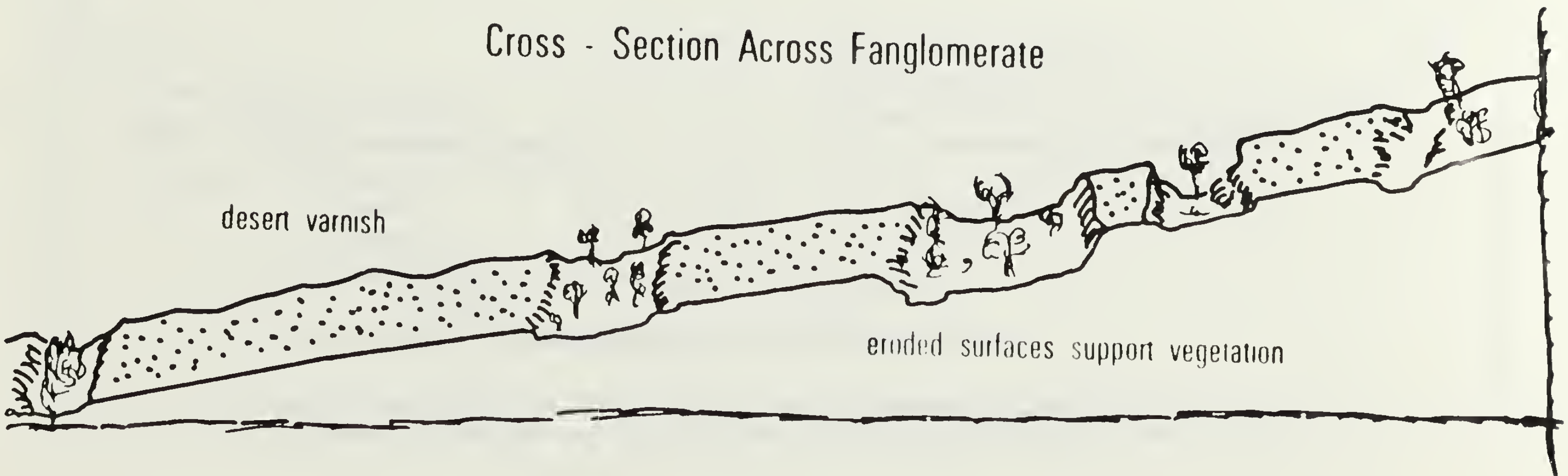


Figure 25

Figure 26 represents generalized altitudinal-aspect-vegetation relationships in the vicinity of Panamint Valley, CA.

The dominant vegetation is keyed accordingly:

pp	pinyon pine
j	juniper
s	sage
jt	joshua tree
cb	creosote bush
sb	saltbush

In the creosote bush-saltbush ecotone specific species of saltbush is dictated by soil factors of texture and salinity.

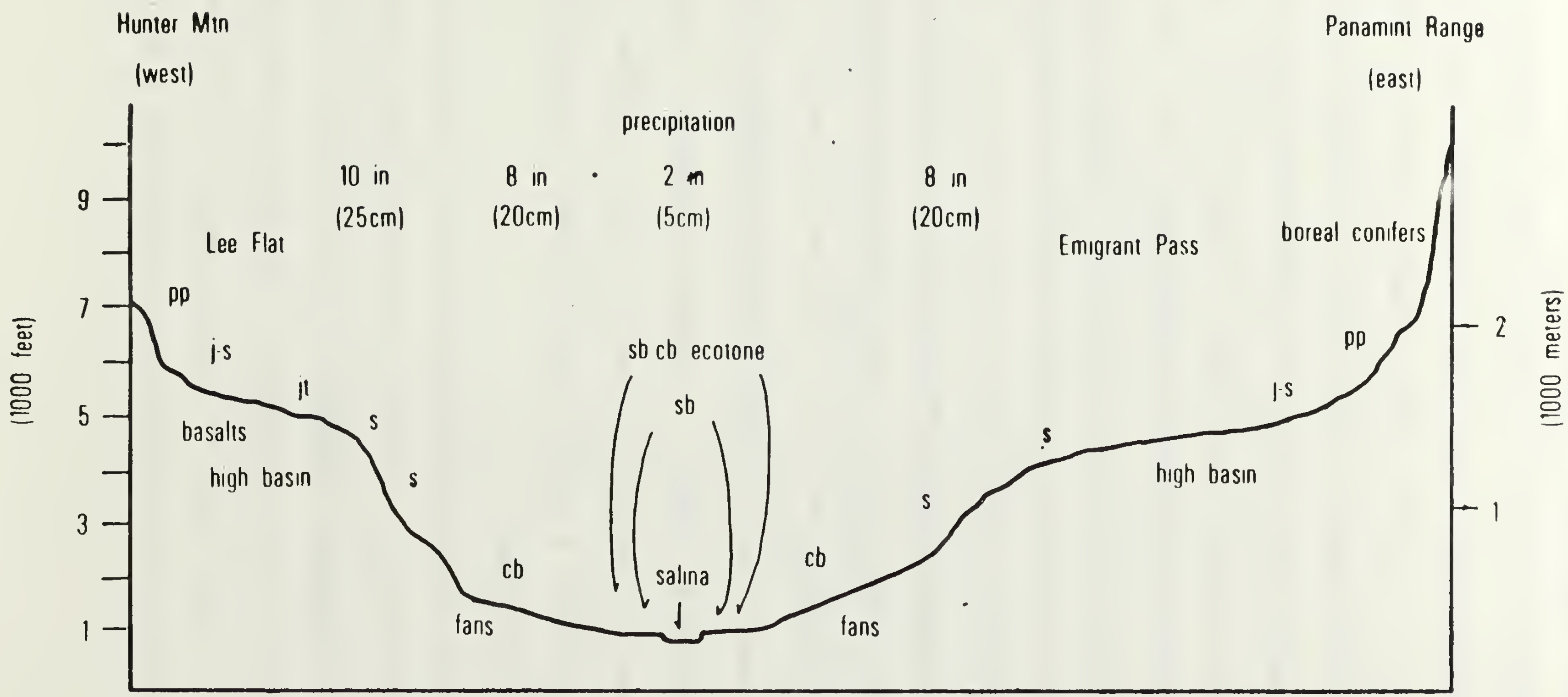

Hunter Mtn
(west)
Panamint Range
(east)
precipitation
10 in
(25cm)
8 in
(20cm)
2 in
(5cm)
8 in
(20cm)
Lee Flat
Emigrant Pass
boreal conifers
pp
j-s
jt
s
s
basalts
high basin
sb cb ecotone
sb
salina
cb
cb
fans
fans
s
s
high basin
j-s
pp
9
7
5
3
1
(1000 feet)
2
1
(1000 meters)

Figure 26

soils because its deep and wide spreading roots reach down to water in the gravels. Desert holly occurs on hot, dry, stony sites usually at the lower levels of fans and can tolerate soil salinities up to two percent. It is most prominent on the stony saline fans on the hot eastern side of Death Valley. As well as forming a nearly pure community below creosote bush, it often forms an ecotonal band with creosote bush. Cattle spinach, another common saltbush species in parts of the Mojave Desert, occurs on fine non-saline silts, usually derived from calcareous parent rocks. It can also form an ecotone with creosote bush.

All three species may be present with creosote occupying the deep gravels, holly saltbush the shallow stony and salty pockets, and cattle spinach present on silty soils.

The saltbushes commonly form a zone of vegetation at the base of fans between the phraetophytes on the playa floor and creosote bush on the stony gravels of the fans.

Burroweed is the least xeric of the xerophytes. It occurs at the highes parts of the fans. Where it is present in washes, it grows on the bottom, whereas desert holly occurs on the dry sides of washes. Incienso (<u>Encelia farinosa</u>) occupies a similar zonal position to burroweed where finer calcareous soils are present.

The roots of phraetophytes have access to perennial ground water. Species of willow (<u>Salix</u>), screwbean mesquite (<u>Prosopsis pubescens</u>) and common reed grass (<u>Phragmites communis</u>) are good indicators of perennial fresh water. A sharp zonal distribution, controlled by both availability and salinity is readily observed flanking playas in the Mojave Desert. Fresh water phraetophytes are associated with springs and seepages on gravel fans.

These grade from the highly tolerant succulent pickleweed (Alenrolfea occidentalis) at the edge of the saltpan, through rush (Juncus cooperi), salt grass (Distichlis stricta) and the salt-tolerant inkweed (Suaeda spp.), alkali sacaton grass (Sporobolus airoides), arroweed (Pluchea sericea) to honey mesquite (Prosopsis juliflora) where salinity is less than 0.5 percent. Although well defined, these zones usually occupy relatively small areas and demonstrate close correspondence between distribution and soil moisture characteristics. Four-wing saltbush (Atriplex canescens) is commonly present adjacent to and within these zones where soils are sandy but nonsaline.

These investigations suggest that some climatic parameters can be used from satellite data to assist in analysis of the biotic patterns in the Mojave Desert. They also infer that in a desert environment, numerous other critical environmental thresholds become increasingly significant. Low rainfall, seasonal regimes, storm paths and index temperatures must be linked to the role of geomorphic units and soil characteristics if a full explanation of plant patterns is to be achieved.

APPENDICES

Appendix A

Questionnaire sent out to desert agencies and residents and responses returned

Appendix B

Harmonic analyses print-outs
Critical Temperatures
(Note: latitude, longitude, elevation omitted or incorrect)

Appendix C

Wind data for all stations located within the CDCA

Appendix D

Definition of terms used on Table 2

Appendix A

UNIVERSITY OF CALIFORNIA, RIVERSIDE

BERKELEY · DAVIS · IRVINE · LOS ANGELES · RIVERSIDE · SAN DIEGO · SAN FRANCISCO · SANTA BARBARA · SANTA CRUZ

DEPARTMENT OF EARTH SCIENCES
Geography — Geology — Geophysics

RIVERSIDE, CALIFORNIA 92521

December 20, 1977

To whom it may concern:

Our department has recently received a small contract from the Bureau of Land Management (BLM) for the purpose of characterizing the climate of the California Desert. Results of the investigation will be used by BLM planning personnel as part of their master plan formulation.

If it is not too great a task, I would appreciate <u>any</u> weather or climatic data your facility records or has in your historical files that would <u>not</u> be part of the Weather Bureau's regularly published information. (We will gladly reimburse you for reproduction costs).

Additionally, we would find <u>personal</u> observations to be of value in our research effort. For example, if one of your employees had witnessed/experienced flash flood conditions or periods of exceptionally high velocity winds we would find such personal accounts <u>most valuable</u>.

One of our primary objectives is to more fully understand the frequency and intensity of temperature inversions that develop in winter in many basins/valleys of the desert. If any of your personnel have data or recollections pertaining to that phenomenon it would be of prime importance to us.

I realize that this request is somewhat vague, but perhaps I can summarize it by stating that <u>any</u> information or observations you or your personnel have about your geographical area on weather/climate conditions are desperately needed by us. As I am sure you realize, the desert area contains few meteorological stations and thus we are attempting to obtain needed information through this method.

I thank you for any assistance or information you can provide us.

Respectfully yours,

James R. Huning
Assistant Research Geographer

JRH/gh

Cima, CA 92323
February 12, 1978

James R. Huning
Assistant Research Geographer
University of California
Dept. of Earth Sciences
Riverside, CA 92521

Dear Sir:

Reference is made to your form letter mailed last month, which requested information regarding desert climate.

Although our experience in the Cima area dates back 51 years, we have never kept any day-by-day weather records during that period. There is some data contained in old family letters and diaries, but these are difficult to locate.

As part of your research I might suggest that you contact Dr. Richard Logan at U.C. L.A. (home address, 943 Sixth St., Apt. E, Santa Monica). We helped Dr. Logan maintain temperature and rainfall instruments at our ranch about 25 years ago, during a rather extensive research project that he conducted here. However, his studies covered only a relatively short period (less than 3 years, I believe), and therefore would probably not include any of the extreme condtions that we occasionally experience here.

Speaking from personal observations, I would say that our weather in the high elevations (4000 to 7000 feet) near Cima is generally unpredictable. We seem to be in an area where erratic weather conditions can be brought about by coastal (or Baja) storms and also by storms coming out of Nevada, Utah, and Colorado. Sudden strong northern winds can lower temperatures radically in just a few hours. I have seen the temperature drop from 50° to 15° in little more than three hours when cold air from Utah or northern Nevada suddenly moves in on us.

We are subject to snow at any time between November 1 and May 31. I can't recall any snowfall as early as October, but I wouldn't discount the possibility. I have seen snow as late as May on a number of occasions. I can recall one incident back in the late Forties when I had to get off my horse and build a fire at noon on the 15th of June in order to get warm. And this was at Granite Well, in Gold Valley, which is on the south (warm) side of the mountain. In other years, June is ordinarily a warm month. But at these higher elevations we actually have only about six months that we can count on for warm weather, and of these months there are only about 60 to 90 days when the weather can get hot (in the 90's). There are few summer days when temperatures go much above 100°, and the nights are always cool.

Flash floods are common nearly every summer, but are rare other times of the year. These floods can turn dry washes into torrential rivers in little more than a half-hour. Unusually heavy winter snows can occur, such as those in the winters of 1937-38 and 1948-49, when snow on the level completely covered four and five foot fences. The 1949 winter was particularly drastic because the heavy snowfall was accompanied by strong winds, which completely buried our buildings under 20-foot drifts. Hundreds of range cattle perished here during that winter, and barbed wire fences broke between each set of posts as a result of the weight of the snow plus the contraction of the metal caused by the extreme cold. Black Canyon was filled completely with snow and the Southcott family of Gold Valley Ranch had to change their mailing address from Cima to Essex because they couldn't get through to Cima for six weeks.

Very few ranchers are still here who remember these extreme winters, and con-

sequently the new people don't prepare for them. But we still remember, and we try to make some preparations each winter, because the big snows will come again when they are least expected. Less severe storms (with snow up to 20 inches deep) occur more frequently, possibly every 5 or 6 years, and there is seldom a winter without at least some snow. Details of the 1949 storm can be verified if you will check newspaper files at the San Bernardino Sun-Telegram for about January 20, 1949.

Winds can also be extreme. Winds up to 50 m.p.h. are fairly common at certain times almost every year. But I personally believe we have occasionally had winds as high as 90 m.p.h., the last occasion being about two years ago when the Mexican storm swept through here. During World War II,I experienced the 1945 typhoon at Okinawa, and I believe I can make a fair estimate of wind velocities.

It is unfortunate that the BLM, which represents Bureaucracy at its worst, has never seen fit to utilize the knowledge and experience of long-time desert residents before starting its various projects. Instead, it tends to employ Eastern college graduates—self-styled "experts"—who formulate programs that accomplish nothing except to harrass local ranchers.

Those of us with many years of experience here could probably come up with more information than the generalities contained in this letter. However, to do so we would need some specific questions to answer. I will be glad to help any way I can.

Very truly yours,

Robert E. Ausmus

Robert E. Ausmus

DEEP SPRINGS COLLEGE
DEEP SPRINGS, CALIFORNIA

POSTAL ADDRESS:
VIA DYER, NEVADA 89010

Jan. 30, 1978

Dear Mr. Huning:

We do not keep any weather information other than what we record for and submit to the U.S. Weather Service--that is, min and max temp and precipitation. I assume you have their published material and, therefore, I'm afraid there is nothing we could add to that.

Sincerely,

Edwin M. Cronk

Edwin M. Cronk
Director and Dean

TELEPHONE DEEP SPRINGS NO. 2

United States Department of the Interior

NATIONAL PARK SERVICE
Death Valley National Monument
Death Valley, California 92328

IN REPLY REFER TO:
N4215

March 14, 1978

James R. Huning
Assistant Research Geographer
University of California
Riverside, CA 92521

Dear Mr. Huning:

Thank you for your letter of December 20, in which you asked for information concerning weather records here at Death Valley.

It has taken us a considerable amount of time to gather the information we felt you wanted. We are enclosing various weather records plus a short paragraph of a personal observation.

We hope this information is helpful to you. If you have need for additional material, please let us know.

Sincerely,

Virgil J. Olson

Virgil J. Olson
Chief Naturalist

United States Department of the Interior

NATIONAL PARK SERVICE

IN REPLY REFER TO:

Enclosed are zeroxed copies of some of our weather data. You will also find a list of the rest of our information. Perhaps you can better tell what we can furnish to you after reading this information. I have also included a conversation with Pauline Esteves. I am not sure this is what you wa want either.

A conversation with Pauline Esteves, a Shoshoni woman working as a seasonal interpreter in Death Valley.

Mrs. Coffinstein, housekeeper at the Inn, says the big winds come every ten years. The ones that take off roofs (tin). She has lived here since 1933(Mrs. Coffinstein)

In the late 20's the heat was so intense that two young women stood on an alluvial fan and heard noises. When they investigated they found it was rocks moving on the fans. They came back and told the Indians what they had discovered and the old ones laughed. Of course this happened. There was even music made up to sound like the moving rocks - old music written before they knew. Also during the twenties the intense heat caused mirages which seemed so close you felt you could touch them without moving.

In the 1800's ther seemed to be more water and more flash floods. Beatty almost washed away. (Don't know date for this because she said cars and trailers were washed away.)

In addition we have:

Hi, Lo, Precip, highest precip. in one storm for
Greenland Ranch, now Furnace Creek Ranch - 1911-1933
Cow Creek (site of first Park Service offices 1934-1960
Furnace Creek Visitor Center - 1961-1969

Record of Evap., water temps., anenometer in miles, 24hr. movement, Ground Temp., cloud and R.H. for:
Furnace Creek V.C. 1967 - date

Temperatures and precipitation for Wildrose - 1974 - part of 1977

U.S. Army - Yuma Proving Groud tested vehicles from 29-Aug-76 to 03-Sep.-76 for Daylite Pass, Towne Pass, Sand Dunes and Panamint Springs. Hi & Lo

STATE OF CALIFORNIA—THE RESOURCES AGENCY

EDMUND G. BROWN JR., Governor

DEPARTMENT OF PARKS AND RECREATION

Providence Mountains Area
P.O. Box 1
Essex, CA 92332

James R. Hunning
Assistant Research Geographer
Department of Earth Sciences
University of California, Riverside
Riverside, CA 92521

February 8, 1978

Dear Mr. Hunning:

Regarding your inquiry about climatic data for Providence Mountains State Recreation Area, we are maintaining a daily record of temperature (max, min) and precipitation. This information is on file with the Environmental Data Service and at our Area Headquarters. Unfortunately, we have no means of reproducing this information, but you are welcome to stop by and review our files.

In addition, we, the staff of Providence Mountains S.R.A. are relatively new to the area and our experience with climatic conditions on the desert is limited. There are, however, several individuals currently residing in the vicinity who have spent much of their life on the Mojave. A visit to the nearby town of Essex or ranches in the area to interview these people may be beneficial to your study.

If we can be of further assistance to you, drop us a line or feel free to stop by the Recreation Area any time.

Sincerely,

William L. Wisehart

William L. Wisehart
State Park Ranger I
Providence Mountains Area

WLW:jc

BORON OPERATIONS

USBORAX
A MEMBER OF THE RTZ GROUP

February 2, 1978

Mr. James R. Huning
Assistant Research Geographer
University of California, Riverside
Riverside, Ca. 92521

Dear Mr. Huning:

Your letter of December 20, 1977 to the Company was passed along to me. I hope the information enclosed will be of some help to you in your compilation of records on the Mojave Desert.

Enclosed are copies of our mine surveyors's record which are incomplete, but may be of some help; the rain gauge used was (and is) a standard Weather Bureau unit calibrated to 1/100 of an inch. Also enclosed is a summary report of the weather station data compiled for one year since it's 1976 installation. Finally, I've enclosed a few graphs which have been kicking around in my files; someone suggested they may have been drafted from raw data collected at Edwards AFB. You may wish to contact EAFB - I'm sure they would be an excellent source.

I wish you success in your project.

Very truly yours,

Joe Siefke

Joe Siefke,
Geologist

sy
Enclosures

UNITED STATES BORAX & CHEMICAL CORPORATION · BORON, CALIFORNIA 93516 · (714) 762-5191

KERR-McGEE CHEMICAL CORP.
TRONA, CALIFORNIA 93562

February 15, 1978

University of California, Riverside
Department of Earth Sciences
Riverside, California 92521

Attention: Mr. James R. Huning
Assistant Research Geographer

Dear Mr. Huning:

In reply to your letter of inquiry dated December 20, 1977, regarding weather data, we can offer you information that dates back to 1920.

This may be of interest to you because the Weather Bureau does not publish all the data we give them. Attached is a copy of some of this data. If this information would be of use to you I will be glad to have it sent to you.

Sincerely,

Gail F. Moulton,
Superintendent,
Geological Operations

GFM:sd

CHEMICALS

San Bernardino Time of observation (local time) if once daily 0830 Month April 19 65
California If at different times, temperature ______ precipitation ______ Standard time in use P

April 65

Temp. Max	Temp. Min	At obsn.	Rain, melted snow, etc. (24-hr amounts)	Dry	Wet	Rel Hum	Important weather conditions, remarks, etc.
70	42	55	0.43	55	48	60	Cloudy
61	44	54	0.07	54	48	65	" (Snow on Summit)
60	44	52	0.06	52	48	75	" " "
54	38	44	0.65	44	44	100	" " "
56	41	50	0.06	50	47	81	" " "
62	42	49	T	49	43	61	Cloudy " "
60	45	56		56	46	45	Clear To Pt. Cloudy
62	46	50	T	50	45	68	Cloudy (Snow on P[illegible]
54	36	50	T	50	47	81	Cloudy " " "
56	34	50	0.11	60	48	37	" " " "
56	25	45		45	43	86	" " " [illegible]
59	39	44	T	44	43	85	" " " [illegible]
61	40	53		53	49	75	Partly Cloudy [illegible]
63	43	54	T	54	52	88	" Haze " "
70	44	62		62	53	55	Clear " "
77	51	63		64	52	43	Cloudy-Haze " "
85	52	65		65	54	48	Clear [illegible]
81	52	66		66	54	45	" Haze "
84	55	59		59	56	83	Partly Cloudy "
70	65	75		75	59	38	Clear "
93	60	73		73	60	40	Partly Cloudy Haze "
92	58	72		72	58	42	" " " "
81	51	67		67	51	30	Clear "
85	56	72		72	52	22	" Breezy "
93	57	59		78	56	53	" windy "
86	60	77		77	55	21	" "
89	59	74		74	56	20	" "
93	63	74		74	55	27	"
92	60	75		75	56	25	" "
95	60	74		74	57	34	Partly Cloudy "
2215	1463	1913	1.38				
[illegible]	[illegible]	[illegible]	.65				
[illegible]	[illegible]	[illegible]					

Observer Am. Potash Chemical Co.
Post Office Trona, Calif

AMERICAN BORATE COMPANY
ROUTE 15 BOX 610
LATHROP WELLS, NEVADA 89020
TEL (702) 873-3770 TELEX 68-4557

HOME OFFICE
2000 WEST LOOP SOUTH
HOUSTON TEXAS 77027
(713) 626-5400

March 13, 1978

James R. Huning
Assistant Research Geographer
Dept. of Earth Sciences
University of California, Riverside
Riverside, CA. 92521

Dear Mr. Huning,

I received your inquirey for information about weather in Death Valley. Although your request, as you state is somewhat vague, we can provide some information from our personal observation, and a minimal amount of temperature information from a weather station we had set up last summer. We have all witnessed and experienced flash flood conditions out in the Death Valley region, as they happen with regularity in late summertime, usually in August. And high velocity winds are a way of life

I can give you some generalizations on the weather out here, but I think that probably the National Park Service, located in Furnace Creek, Death Valley National Monument, California, can provide you with more of the specifics that would be of use to you. They do have a weather station there. I don't know if they record temperature, or temperature and barometric pressure, but they would have some information.

Enclosed please find copies of some of our thermograph tapes taken in the summer of 1976 at an approximate elevation of 3100 ft., located about 12 miles west of Death Valley Junction on Highway 190.

For any specific request you may have I would advise calling me at area code 714-786-2241, and I'd be happy to talk about them with you.

Sincerely,

James C. Norman

James C. Norman
Technical Support Coordinator

JCN;sh

Appendix B

Appendix B consists of a listing of stations and their mean monthly temperatures for which harmonic analysis of temperature was performed, and print-outs of the harmonic analysis calculations, including number of days with various critical temperatures.

```
1     BISHOP AP                                   4108
      3 36.8 40.7 47.1 55.1 62.6 69.8 76.1 73.8 67.7 56.9 45.8 39.3
      5
1     BLYTHE                                       268
      3 52.6 57.0 63.4 70.9 77.6 85.1 92.1 91.0 85.5 73.4 60.1 53.8
      5
1     BRAWLEY 2 SW                                -100
      3 53.9 58.0 64.1 71.5 78.6 86.0 92.9 92.3 87.5 75.8 62.6 55.7
      5
1     DEATH VALLEY                                -194
      3 52.0 58.2 67.3 77.0 85.1 93.9101.6 99.1 90.9 77.0 61.5 53.1
      5
1     EL CENTRO 2 SW                               -30
      3 53.6 57.6 63.6 70.8 78.0 85.4 92.2 91.2 86.3 74.9 62.1 55.2
      5
1     HAIWEE                                      3825
      3 39.8 43.8 49.9 58.2 65.5 73.9 81.1 79.1 73.1 61.5 49.2 41.8
      5
1     FAIRMONT                                    3060
      3 43.5 45.7 49.8 56.1 62.0 70.2 79.2 78.1 73.5 62.9 52.1 45.8
      5
1     IMPERIAL                                     -64
      3 54.1 58.0 63.6 70.9 77.8 85.1 91.8 90.8 86.0 74.8 62.3 55.9
      5
1     INDIO US DATE GARDEN                          11
      3 54.1 58.1 64.5 72.3 79.1 86.4 92.1 90.6 86.1 75.5 62.9 55.8
      5
1     PALMDALE                                    2596
      3 44.5 47.6 52.5 58.7 65.2 72.9 81.5 80.0 74.4 63.6 52.3 46.2
      5
1     PALM SPRINGS                                 411
      3 53.9 57.3 62.7 69.7 75.8 82.9 90.6 88.9 84.1 74.1 62.5 55.7
      5
1     SQUIRREL INN 2                              5680
      3 38.8 39.9 43.4 48.3 53.6 61.2 69.1 68.7 65.1 55.2 46.8 41.7
      5
1     TABLE MOUNTAIN
      3 33.5 33.5 37.2 44.0 51.5 60.1 67.6 67.0 61.8 51.2 42.4 36.9
      5
1     TRONA                                       1695
      3 45.1 50.6 57.4 65.8 73.6 81.6 89.4 87.2 80.3 68.0 53.9 46.1
      5
1     PARKER                                       425
      3 51.5 56.3 62.5 70.3 77.8 86.3 93.4 91.7 85.6 73.5 59.9 53.1
      5
1     YUMA CITRUS CITRUS STATION                   191
      3 53.3 57.0 62.6 69.6 76.5 83.9 91.6 90.8 85.8 74.1 61.7 55.3
      5
1     YUMA AP                                      194
      3 56.4 60.1 66.0 72.9 80.1 87.7 94.8 93.5 89.1 77.3 64.4 58.0
      5
1     LAS VEGAS AP                                2162
      3 43.6 48.3 55.3 65.0 73.8 83.4 90.2 87.7 80.5 67.1 53.0 45.1
      5
1     BOULDER CITY                                2525
      3 45.7 49.6 56.7 65.6 73.8 82.7 89.1 86.9 81.2 68.8 55.2 47.9
      5
1     ADAVEN                                      6250
      3 29.0 31.4 37.7 46.2 53.8 62.6 70.2 68.3 61.8 50.4 39.1 32.7
      5
1     CALIENTE                                    4402
      3 30.4 36.2 43.8 52.3 60.3 68.6 76.0 74.0 66.2 54.1 41.6 33.9
      5
1     MINA                                        4552
      3 32.1 36.8 43.3 51.8 60.3 69.5 78.2 75.7 66.5 54.3 41.4 34.4
      5
```

```
1   BOUSE,AZ                                     930
3 49.8 54.1 59.0 66.8 75.6 84.1 91.9 90.7 83.1 71.3 57.8 49.7  69.5
5
1   EHRENBERG                                    323
3 52.9 57.8 62.5 70.9 78.5 85.9 92.5 91.6 85.8 74.0 61.2 53.7  72.3
5
1   KINGMAN                                     3360
3 43.4 46.6 50.6 58.6 66.6 74.9 82.3 80.1 74.4 64.2 52.4 45.2  61.6
5
1   KOFA    MTNS                                1775
3 55.7 59.3 62.9 70.1 76.9 85.8 91.3 90.1 85.6 76.3 63.8 56.6  72.9
5
1   QUARTZITE                                    890
3 50.9 56.7 62.2 69.3 78.8 87.5 94.8 92.9 85.4 74.4 60.8 50.4  72.0
5
1   BARSTOW                                     2160
3 46.2 50.4 55.2 63.1 69.8 78.7 85.6 82.9 77.9 65.7 52.9 46.3  64.6
5
1   DAGGETT FAA AP                              1915
3 48.0 51.8 56.9 64.8 72.0 81.0 87.7 85.4 80.3 68.4 55.0 48.5  66.7
5
1   DEEP SPRINGS                                5223
3 30.5 36.8 43.4 51.8 58.7 69.4 75.0 71.9 66.4 54.2 41.7 34.2  52.8
5
1   INYOKERN                                    2440
3 44.9 48.9 54.0 61.3 69.0 78.9 84.8 82.0 76.7 65.3 52.2 45.5  63.6
5
1   IRON MOUNTAIN                                922
3 53.2 57.2 62.9 71.8 79.4 89.1 95.2 92.7 88.3 76.1 62.2 54.9  73.6
5
1   LANCASTER                                   2340
3 43.8 47.2 51.6 59.0 65.8 74.3 82.1 79.4 74.3 62.7 49.8 43.4  61.1
5
1   LUCERNE VALLEY
3 42.9 45.9 51.3 58.6 65.7 74.5 81.7 79.0 72.9 61.6 49.2 43.5  60.6
5
1   MECCA 3 SE                                  -180
3 53.9 57.9 63.3 70.7 77.3 84.5 90.8 88.9 85.6 75.1 62.3 55.4  72.1
5
1   NEEDLES                                      480
3 51.9 55.9 61.7 70.7 79.3 89.4 95.3 92.6 87.5 74.6 60.0 53.1  72.7
5
1   RANDSBURG                                   3570
3 44.5 47.7 52.1 60.0 67.3 76.7 84.2 81.8 76.8 65.3 52.6 46.6  63.0
5
1   THERMAL FAA AP                              -112
3 54.6 58.4 63.6 71.7 78.6 86.8 92.8 90.5 86.7 75.4 62.0 55.6  73.1
5
1   TWENTYNINE PALMS                            1975
3 49.4 53.2 58.1 66.5 73.6 82.9 89.2 86.9 81.8 70.1 57.1 50.4  68.3
5
1   VICTORVILLE                                 2858
3 43.5 46.3 50.4 57.4 63.6 72.2 79.6 77.8 73.4 62.5 50.3 44.4  60.1
5
```

```
NAME=BISHOP AP                                 ID=
ALTITUDE= 4108M          LAT= 0   ON          LONG=   0   OW
--------------------------------------------------------------------------------
HARMONIC COMPONENTS
           ANGLE                 AMPLITUDE
 1 266.76525879               18.87660980
 2   6.14378071                1.71302056
 3 247.16656494                 .34359419
 4 119.99971008                 .28867501
 5 273.73944092                 .48783547
 6  90.00000000                 .04166666

  MEAN = 55.975014         VARIANCE = .00000
--------------------------------------------------------------------------------
INPUT DATA                                              (X SHIFT=13.5 DEGREES)
   MO.  INPUT TEMP  CALCULATED TEMP   MO.  INPUT TEMP  CALCULATED TEMP
    1..... 36.8000........ 36.79999    7..... 76.1000........ 76.09998
    2..... 40.7000........ 40.70000    8..... 73.8000........ 73.79997
    3..... 47.1000........ 47.09999    9..... 67.7000........ 67.69997
    4..... 55.1000........ 55.10000   10..... 56.9000........ 56.90000
    5..... 62.6000........ 62.59999   11..... 45.8000........ 45.80001
    6..... 69.8000........ 69.79994   12..... 39.3000........ 39.30000
--------------------------------------------------------------------------------
LOCAL MINIMUM(S)=    36.75901
DAY NUMBER(S)/LAG     11/  20

LOCAL MAXIMUM(S)=    76.31412
DAY NUMBER(S)/LAG    203/  31

CRITICAL TEMPS  DAYS >  50.000  DAYS >  86.000  DAYS <  43.600      TD
NUMBER OF DAYS              218               0              97      .0
```

```
NAME=BLYTHE                                 ID=
ALTITUDE=  268M        LAT= 0   ON         LONG=  0   OW
--------------------------------------------------------------------
HARMONIC COMPONENTS
          ANGLE               AMPLITUDE
 1 266.13159180            19.35266876
 2   1.79193783             2.93148470
 3 153.43554688              .03726584
 4 128.94845581              .48217976
 5 272.78521729              .45863360
 6  90.00000000              .00833448

  MEAN = 71.875015         VARIANCE = .00000
--------------------------------------------------------------------
INPUT DATA                                       (X SHIFT=13.5 DEGREES)
   MO.   INPUT TEMP  CALCULATED TEMP   MO.  INPUT TEMP  CALCULATED TEMP
    1..... 52.6000........ 52.59999    7..... 92.1000........ 92.09996
    2..... 57.0000........ 56.99999    8..... 91.0000........ 90.99997
    3..... 63.4000........ 63.39999    9..... 85.5000........ 85.49998
    4..... 70.9000........ 70.89995   10..... 73.4000........ 73.39996
    5..... 77.6000........ 77.59996   11..... 60.1000........ 60.10000
    6..... 85.1000........ 85.09996   12..... 53.8000........ 53.80000
--------------------------------------------------------------------
LOCAL MINIMUM(S)=    52.36492
DAY NUMBER(S)/LAG      6/  15

LOCAL MAXIMUM(S)=    92.58249
DAY NUMBER(S)/LAG    207/  35

CRITICAL TEMPS  DAYS >  50.000  DAYS >  86.000  DAYS <  43.600      TD
NUMBER OF DAYS             365             87               0      .0
```

```
NAME=BRAWLEY 2 SW                                ID=
ALTITUDE= -100M          LAT= 0   ON           LONG=   0   OW
--------------------------------------------------------------------------------
HARMONIC COMPONENTS
          ANGLE                  AMPLITUDE
 1 263.67449951               19.22457504
 2 356.86914063                2.74651432
 3  53.12947083                 .08333467
 4 132.51977539                 .38441610
 5 272.25714111                 .45948130
 6  90.00000000                 .02500025

  MEAN = 73.241669         VARIANCE = .00000
--------------------------------------------------------------------------------
INPUT DATA                                                (X SHIFT=13.5 DEGREES)
   MO.   INPUT TEMP   CALCULATED TEMP    MO.   INPUT TEMP   CALCULATED TEMP
    1..... 53.9000........ 53.89997      7..... 92.9000........ 92.89995
    2..... 58.0000........ 57.99998      8..... 92.3000........ 92.29997
    3..... 64.1000........ 64.09996      9..... 87.5000........ 87.49997
    4..... 71.5000........ 71.49995     10..... 75.8000........ 75.79996
    5..... 78.6000........ 78.59998     11..... 62.6000........ 62.59997
    6..... 86.0000........ 85.99994     12..... 55.7000........ 55.69999
--------------------------------------------------------------------------------
LOCAL MINIMUM(S)=    53.76945
DAY NUMBER(S)/LAG      9/  18

LOCAL MAXIMUM(S)=    93.48886
DAY NUMBER(S)/LAG    208/  36

CRITICAL TEMPS   DAYS >  50.000   DAYS >  86.000   DAYS <  43.600       TD
NUMBER OF DAYS               365               97                0       .0
```

```
NAME=DEATH VALLEY                              ID=
ALTITUDE= -194M          LAT= 0   0N          LONG=  0  0W
-------------------------------------------------------------------------------
HARMONIC COMPONENTS
           ANGLE                 AMPLITUDE
 1 269.98010254                 23.99237823
 2 358.03710938                  3.16284895
 3 267.61389160                   .40034986
 4 110.25991821                   .54185760
 5 268.82855225                   .40770644
 6  90.00000000                   .00833448

  MEAN = 76.391678          VARIANCE = .00000
-------------------------------------------------------------------------------
INPUT DATA                                              (X SHIFT=13.5 DEGREES)
   MO.  INPUT TEMP  CALCULATED TEMP     MO.  INPUT TEMP  CALCULATED TEMP
    1..... 52.0000........ 51.99998      7.....101.6000........101.59998
    2..... 58.2000........ 58.19999      8..... 99.1000........ 99.09996
    3..... 67.3000........ 67.29997      9..... 90.9000........ 90.89996
    4..... 77.0000........ 76.99995     10..... 77.0000........ 76.99997
    5..... 85.1000........ 85.09999     11..... 61.5000........ 61.50001
    6..... 93.9000........ 93.89995     12..... 53.1000........ 53.09999
-------------------------------------------------------------------------------
LOCAL MINIMUM(S)=    51.50187
DAY NUMBER(S)/LAG      4/  13

LOCAL MAXIMUM(S)=  101.94981
DAY NUMBER(S)/LAG    204/  32

CRITICAL TEMPS   DAYS >  50.000  DAYS >  86.000  DAYS <  43.600      TD
NUMBER OF DAYS              365             131               0      .0
```

```
NAME=EL CENTRO 2 SW                            ID=
ALTITUDE=   -30M          LAT= 0   ON         LONG=  0  OW
-----------------------------------------------------------------------
HARMONIC COMPONENTS
          ANGLE                 AMPLITUDE
 1 264.10205078              18.95909119
 2 359.26483154               2.59829140
 3      .00013737              .11666587
 4 127.58895874               .37859237
 5 271.92510986               .44151360
 6  90.00000000               .05833434

  MEAN = 72.574997        VARIANCE = .00000
-----------------------------------------------------------------------
INPUT DATA                                    (X SHIFT=13.5 DEGREES)
   MO.  INPUT TEMP  CALCULATED TEMP   MO.  INPUT TEMP  CALCULATED TEMP
    1..... 53.6000........ 53.59997    7..... 92.2000........ 92.19994
    2..... 57.6000........ 57.59998    8..... 91.2000........ 91.19995
    3..... 63.6000........ 63.59996    9..... 86.3000........ 86.29996
    4..... 70.8000........ 70.79997   10..... 74.9000........ 74.89996
    5..... 78.0000........ 77.99995   11..... 62.1000........ 62.09997
    6..... 85.4000........ 85.39993   12..... 55.2000........ 55.19997
-----------------------------------------------------------------------
LOCAL MINIMUM(S)=    53.43810
DAY NUMBER(S)/LAG      8/  17

LOCAL MAXIMUM(S)=    92.66830
DAY NUMBER(S)/LAG    207/  35

CRITICAL TEMPS   DAYS >  50.000  DAYS >  86.000  DAYS <  43.600      TD
NUMBER OF DAYS      .       365              91               0      .0
```

```
NAME=HAIWEE                                    ID=
ALTITUDE= 3825M         LAT= 0   ON            LONG=  0  OW
---------------------------------------------------------------------------------
HARMONIC COMPONENTS
          ANGLE                 AMPLITUDE
 1 264.79638672              19.98571396
 2   7.00762844               2.25407410
 3 273.17968750                .30046278
 4 111.24728394                .43811351
 5 291.86798096                .48128122
 6  90.00000000                .02500089

  MEAN = 59.741676        VARIANCE = .00000
---------------------------------------------------------------------------------
INPUT DATA                                              (X SHIFT=13.5 DEGREES)
   MO.  INPUT TEMP  CALCULATED TEMP   MO.  INPUT TEMP  CALCULATED TEMP
    1..... 39.8000........ 39.79997     7..... 81.1000........ 81.09996
    2..... 43.8000........ 43.80000     8..... 79.1000........ 79.09996
    3..... 49.9000........ 49.89998     9..... 73.1000........ 73.09999
    4..... 58.2000........ 58.19999    10..... 61.5000........ 61.50000
    5..... 65.5000........ 65.49995    11..... 49.2000........ 49.19999
    6..... 73.9000........ 73.89995    12..... 41.8000........ 41.79999
---------------------------------------------------------------------------------
LOCAL MINIMUM(S)=    39.63088
DAY NUMBER(S)/LAG      8/  17

LOCAL MAXIMUM(S)=    81.36804
DAY NUMBER(S)/LAG    204/  32

CRITICAL TEMPS  DAYS >  50.000  DAYS >  86.000  DAYS <  43.600     TD
NUMBER OF DAYS              241               0              69      .0
```

```
NAMF=FAIRMONT                                   ID=
ALTITUDE= 3060M          LAT= 0   ON           LONG=  0   OW
----------------------------------------------------------------------
HARMONIC COMPONENTS
          ANGLE                AMPLITUDE
 1 257.38885498             17.36736679
 2  18.40870285              2.58607435
 3 240.25497437               .40311390
 4 111.36083984               .55477548
 5 289.17779541               .58403730
 6  90.00000000               .10833293

  MEAN = 59.908348        VARIANCE = .00000
----------------------------------------------------------------------
INPUT DATA                                       (X SHIFT=13.5 DEGREES)
   MO.  INPUT TEMP  CALCULATED TEMP   MO.  INPUT TEMP  CALCULATED TEMP
    1..... 43.5000........ 43.49998    7..... 79.2000........ 79.19995
    2..... 45.7000........ 45.70000    8..... 78.1000........ 78.09999
    3..... 49.8000........ 49.80000    9..... 73.5000........ 73.49997
    4..... 56.1000........ 56.10000   10..... 62.9000........ 62.90001
    5..... 62.0000........ 61.99998   11..... 52.1000........ 52.10000
    6..... 70.2000........ 70.19995   12..... 45.8000........ 45.80000
----------------------------------------------------------------------
LOCAL MINIMUM(S)=   43.48852
DAY NUMBER(S)/LAG    13/  22

LOCAL MAXIMUM(S)=   79.79674
DAY NUMBER(S)/LAG   207/  35

CRITICAL TEMPS  DAYS >  50.000  DAYS >  86.000  DAYS <  43.600      TD
NUMBER OF DAYS            251             0              13       .0
```

```
NAME=IMPERIAL                                    ID=
ALTITUDE=  -64M         LAT= 0  ON           LONG=  0  OW
----------------------------------------------------------------------
HARMONIC COMPONENTS
          ANGLE                AMPLITUDE
 1 263.95989990              18.49325943
 2     .95596349              2.49738598
 3  33.68746185                .06009400
 4 128.51300049                .39405030
 5 275.32525635                .49487352
 6  90.00000000                .00833320

  MEAN = 72.591690        VARIANCE = .00000
----------------------------------------------------------------------
INPUT DATA                                          (X SHIFT=13.5 DEGREES)
   MO.  INPUT TEMP  CALCULATED TEMP    MO.  INPUT TEMP  CALCULATED TEMP
    1..... 54.1000........ 54.09999     7..... 91.8000........ 91.79999
    2..... 58.0000........ 57.99999     8..... 90.8000........ 90.79999
    3..... 63.6000........ 63.60000     9..... 86.0000........ 85.99998
    4..... 70.9000........ 70.89996    10..... 74.8000........ 74.79997
    5..... 77.8000........ 77.79999    11..... 62.3000........ 62.30002
    6..... 85.1000........ 85.09996    12..... 55.9000........ 55.90000
----------------------------------------------------------------------
LOCAL MINIMUM(S)=    53.98096
DAY NUMBER(S)/LAG      9/  18

LOCAL MAXIMUM(S)=    92.24559
DAY NUMBER(S)/LAG    207/  35

CRITICAL TEMPS   DAYS >  50.000  DAYS >  86.000  DAYS <  43.600      TD
NUMBER OF DAYS               365              89               0      .0
```

```
NAME=INDIO US DATE GARDEN                    ID=
ALTITUDE=   11M          LAT= 0   0N         LONG=  0  0W
----------------------------------------------------------------------
HARMONIC COMPONENTS
          ANGLE                 AMPLITUDE
 1 265.47564697               18.64914322
 2 349.38842773                2.21741962
 3 351.25360107                 .21921352
 4 128.94805908                 .48218036
 5 283.14965820                 .38575035
 6  90.00000000                 .00833448

  MEAN = 73.125015        VARIANCE = .00000
----------------------------------------------------------------------
INPUT DATA                                          (X SHIFT=13.5 DEGREES)
   MO.   INPUT TEMP  CALCULATED TEMP    MO.   INPUT TEMP   CALCULATED TEMP
    1..... 54.1000........ 54.09998      7..... 92.1000........ 92.09998
    2..... 58.1000........ 58.09998      8..... 90.6000........ 90.59995
    3..... 64.5000........ 64.49998      9..... 86.1000........ 86.09999
    4..... 72.3000........ 72.29996     10..... 75.5000........ 75.49995
    5..... 79.1000........ 79.09998     11..... 62.9000........ 62.90000
    6..... 86.4000........ 86.39996     12..... 55.8000........ 55.80000
----------------------------------------------------------------------
LOCAL MINIMUM(S)=    53.94053
DAY NUMBER(S)/LAG      8/  17

LOCAL MAXIMUM(S)=    92.29462
DAY NUMBER(S)/LAG    204/  32

CRITICAL TEMPS   DAYS >  50.000   DAYS >  86.000   DAYS <  43.600      TD
NUMBER OF DAYS              365                93                0      .0
```

```
NAME=PALMDALE                                    ID=
ALTITUDE= 2596M          LAT= 0   ON             LONG=  0  OW
-----------------------------------------------------------------------
HARMONIC COMPONENTS
          ANGLE                  AMPLITUDE
 1 261.62481689               17.78669739
 2  17.37308502                2.70714092
 3 250.01705933                 .39015919
 4 105.82376099                 .47638601
 5 270.78747559                 .53636658
 6  90.00000000                 .11666742

  MEAN = 61.616669          VARIANCE = .00000
-----------------------------------------------------------------------
INPUT DATA                                        (X SHIFT=13.5 DEGREES)
   MO.  INPUT TEMP  CALCULATED TEMP    MO.  INPUT TEMP  CALCULATED TEMP
    1..... 44.5000........ 44.49997     7..... 81.5000........ 81.49995
    2..... 47.6000........ 47.59998     8..... 80.0000........ 79.99997
    3..... 52.5000........ 52.49998     9..... 74.4000........ 74.39993
    4..... 58.7000........ 58.69998    10..... 63.6000........ 63.59998
    5..... 65.2000........ 65.19994    11..... 52.3000........ 52.30000
    6..... 72.9000........ 72.89993    12..... 46.2000........ 46.19999
-----------------------------------------------------------------------
LOCAL MINIMUM(S)=    44.42737
DAY NUMBER(S)/LAG     10/  19

LOCAL MAXIMUM(S)=    82.09261
DAY NUMBER(S)/LAG    206/  34

CRITICAL TEMPS  DAYS >  50.000  DAYS >  86.000  DAYS <  43.600     TD
NUMBER OF DAYS              267               0               0     .0
```

```
NAME=PALM SPRINGS                            ID=
ALTITUDE=  411M          LAT= 0  ON          LONG=  0  OW
------------------------------------------------------------------------
HARMONIC COMPONENTS
          ANGLE                 AMPLITUDE
 1 262.61004639               17.64191818
 2   2.25887537                2.32564306
 3 270.00054932                 .33333290
 4 103.09736633                 .57324719
 5 277.55468750                 .52585268
 6  90.00000000                 .08333524

  MEAN = 71.516663         VARIANCE = .00000
------------------------------------------------------------------------
INPUT DATA                                          (X SHIFT=13.5 DEGREES)
   MO.  INPUT TEMP  CALCULATED TEMP    MO.  INPUT TEMP  CALCULATED TEMP
    1..... 53.9000........ 53.89997     7..... 90.6000........ 90.59998
    2..... 57.3000........ 57.29998     8..... 88.9000........ 88.89993
    3..... 62.7000........ 62.69997     9..... 84.1000........ 84.09996
    4..... 69.7000........ 69.69994    10..... 74.1000........ 74.09998
    5..... 75.8000........ 75.79994    11..... 62.5000........ 62.49998
    6..... 82.9000........ 82.89995    12..... 55.7000........ 55.69997
------------------------------------------------------------------------
LOCAL MINIMUM(S)=    53.78803
DAY NUMBER(S)/LAG      9/  18

LOCAL MAXIMUM(S)=    91.00609
DAY NUMBER(S)/LAG    205/  33

CRITICAL TEMPS   DAYS >  50.000   DAYS >  86.000   DAYS <  43.600      TD
NUMBER OF DAYS               365               71                0     .0
```

```
NAME=SQUIRREL INN 2                            ID=
ALTITUDE= 5680M          LAT= 0   ON          LONG=  0  OW
----------------------------------------------------------------------
HARMONIC COMPONENTS
          ANGLE                AMPLITUDE
 1 254.19323730              14.96228790
 2  25.49836349               2.20680857
 3 216.86999512                .50000024
 4 149.99981689                .39999998
 5 296.45220947                .50652719
 6  90.00000000                .15000215

  MEAN = 52.650002         VARIANCE = .00000
----------------------------------------------------------------------
INPUT DATA                                          (X SHIFT=13.5 DEGREES)
   MO.  INPUT TEMP  CALCULATED TEMP    MO.  INPUT TEMP  CALCULATED TEMP
    1..... 38.8000........ 38.79999     7..... 69.1000........ 69.09996
    2..... 39.9000........ 39.89999     8..... 68.7000........ 68.69995
    3..... 43.4000........ 43.39998     9..... 65.1000........ 65.09999
    4..... 48.3000........ 48.29997    10..... 55.2000........ 55.19997
    5..... 53.6000........ 53.59998    11..... 46.8000........ 46.79999
    6..... 61.2000........ 61.19997    12..... 41.7000........ 41.69997
----------------------------------------------------------------------
LOCAL MINIMUM(S)=    38.72429
DAY NUMBER(S)/LAG     20/  29

LOCAL MAXIMUM(S)=    69.69589
DAY NUMBER(S)/LAG    208/  36

CRITICAL TEMPS  DAYS >  50.000  DAYS >  86.000  DAYS <  43.600      TD
NUMBER OF DAYS            189               0              104      .0
```

```
NAME=TABLE MOUNTAIN                         ID=
ALTITUDE=    OM          LAT= 0  ON        LONG=  0  OW
---------------------------------------------------------------------
HARMONIC COMPONENTS
          ANGLE                 AMPLITUDE
 1 255.55487061               17.21997833
 2  47.75205231                1.84624243
 3 187.35244751                 .52095032
 4 141.55532837                 .29486251
 5 300.17199707                 .35595316
 6  90.00000000                 .10833421

  MEAN = 48.891670        VARIANCE = .00000
---------------------------------------------------------------------
INPUT DATA                                   (X SHIFT=13.5 DEGREES)
   MO.   INPUT TEMP  CALCULATED TEMP   MO.  INPUT TEMP  CALCULATED TEMP
    1..... 33.5000........ 33.49997     7..... 67.6000........ 67.59996
    2..... 33.5000........ 33.49998     8..... 67.0000........ 66.99997
    3..... 37.2000........ 37.19998     9..... 61.8000........ 61.79998
    4..... 44.0000........ 43.99998    10..... 51.2000........ 51.19999
    5..... 51.5000........ 51.49997    11..... 42.4000........ 42.39999
    6..... 60.1000........ 60.09998    12..... 36.9000........ 36.89999
---------------------------------------------------------------------
LOCAL MINIMUM(S)=    33.04902
DAY NUMBER(S)/LAG     30/  39

LOCAL MAXIMUM(S)=    68.19518
DAY NUMBER(S)/LAG    208/  36

CRITICAL TEMPS  DAYS >  50.000  DAYS >  86.000  DAYS <  43.600    TD
NUMBER OF DAYS             161               0             156    .0
```

```
NAME=TRONA                                      ID=
ALTITUDE=16950M        LAT= 0   ON            LONG=  0  OW
----------------------------------------------------------------------
HARMONIC COMPONENTS
          ANGLE                AMPLITUDE
 1 267.53082275             21.35990143
 2   2.76797628              2.93347359
 3 302.90557861               .33747482
 4  91.68145752               .49187589
 5 270.38610840               .52660584
 6  90.00000000               .03333346

  MEAN = 66.583344         VARIANCE = .00000
----------------------------------------------------------------------
INPUT DATA                                          (X SHIFT=13.5 DEGREES)
   MO.  INPUT TEMP  CALCULATED TEMP   MO.  INPUT TEMP  CALCULATED TEMP
    1..... 45.1000........ 45.09999    7..... 89.4000........ 89.39993
    2..... 50.6000........ 50.59998    8..... 87.2000........ 87.19997
    3..... 57.4000........ 57.39999    9..... 80.3000........ 80.29997
    4..... 65.8000........ 65.79996   10..... 68.0000........ 67.99998
    5..... 73.6000........ 73.59998   11..... 53.9000........ 53.90001
    6..... 81.6000........ 81.59999   12..... 46.1000........ 46.09998
----------------------------------------------------------------------
LOCAL MINIMUM(S)=    44.57981
DAY NUMBER(S)/LAG      4/  13

LOCAL MAXIMUM(S)=    89.80554
DAY NUMBER(S)/LAG    205/  33

CRITICAL TEMPS  DAYS >  50.000  DAYS >  86.000  DAYS <  43.600      TD
NUMBER OF DAYS             288              53               0      .0
```

```
NAME=PARKER                                    ID=
ALTITUDE=  425M          LAT= 0  ON            LONG=  0  OW
------------------------------------------------------------------------
HARMONIC COMPONENTS
          ANGLE                 AMPLITUDE
 1 265.86633301               20.35450363
 2   6.58668900                2.76063585
 3 318.01336670                 .22422794
 4 126.58683777                 .43588758
 5 273.88989258                 .49959397
 6 270.00000000                 .04166666

  MEAN = 71.824997         VARIANCE = .00000
------------------------------------------------------------------------
INPUT DATA                                         (X SHIFT=13.5 DEGREES)
   MO.  INPUT TEMP  CALCULATED TEMP   MO.  INPUT TEMP  CALCULATED TEMP
    1..... 51.5000........ 51.49997    7..... 93.4000........ 93.39993
    2..... 56.3000........ 56.29998    8..... 91.7000........ 91.69994
    3..... 62.5000........ 62.49997    9..... 85.6000........ 85.59996
    4..... 70.3000........ 70.29996   10..... 73.5000........ 73.49995
    5..... 77.8000........ 77.79994   11..... 59.9000........ 59.89999
    6..... 86.3000........ 86.29994   12..... 53.1000........ 53.09998
------------------------------------------------------------------------
LOCAL MINIMUM(S)=    51.27002
DAY NUMBER(S)/LAG      7/  16

LOCAL MAXIMUM(S)=    93.75398
DAY NUMBER(S)/LAG    205/  33

CRITICAL TEMPS  DAYS >  50.000  DAYS >  86.000  DAYS <  43.600      TD
NUMBER OF DAYS             365              91               0      .0
```

```
NAME=YUMA CITRUS CITRUS STATION              ID=
ALTITUDE=  191M        LAT= 0  ON           LONG=  0  OW
-----------------------------------------------------------------------
HARMONIC COMPONENTS
          ANGLE                AMPLITUDE
 1 262.64343262              18.71067810
 2   4.91463089               2.72356129
 3 203.19845581                .12693056
 4 127.58862305                .37859541
 5 273.06597900                .54411697
 6  90.00000000                .06666628

  MEAN = 71.850006        VARIANCE = .00000
-----------------------------------------------------------------------
INPUT DATA                                          (X SHIFT=13.5 DEGREES)
   MO.   INPUT TEMP  CALCULATED TEMP    MO.   INPUT TEMP  CALCULATED TEMP
    1..... 53.3000........ 53.30000     7..... 91.6000........ 91.59998
    2..... 57.0000........ 56.99998     8..... 90.8000........ 90.79994
    3..... 62.6000........ 62.59998     9..... 85.8000........ 85.79996
    4..... 69.6000........ 69.59996    10..... 74.1000........ 74.09998
    5..... 76.5000........ 76.49997    11..... 61.7000........ 61.69999
    6..... 83.9000........ 83.89996    12..... 55.3000........ 55.29999
-----------------------------------------------------------------------
LOCAL MINIMUM(S)=    53.22616
DAY NUMBER(S)/LAG     10/  19

LOCAL MAXIMUM(S)=    92.23262
DAY NUMBER(S)/LAG    208/  36

CRITICAL TEMPS   DAYS >  50.000   DAYS >  86.000   DAYS <  43.600      TD
NUMBER OF DAYS              365               84                0      .0
```

```
NAME=YUMA AP                                      ID=
ALTITUDE=  194M          LAT= 0   ON          LONG=  0   OW
--------------------------------------------------------------------------------
HARMONIC COMPONENTS
          ANGLE                 AMPLITUDE
 1 263.57696533               18.85941315
 2   3.03688097                2.67400122
 3  29.74518204                .13437340
 4 140.17355347                .50744379
 5 272.87847900                .52629912
 6  90.00000000                .10833484

  MEAN = 75.025009          VARIANCE = .00000
--------------------------------------------------------------------------------
INPUT DATA                                               (X SHIFT=13.5 DEGREES)
   MO.  INPUT TEMP  CALCULATED TEMP    MO.  INPUT TEMP  CALCULATED TEMP
    1..... 56.4000........ 56.39999      7..... 94.8000........ 94.79997
    2..... 60.1000........ 60.09998      8..... 93.5000........ 93.50000
    3..... 66.0000........ 65.99995      9..... 89.1000........ 89.09999
    4..... 72.9000........ 72.89998     10..... 77.3000........ 77.29996
    5..... 80.1000........ 80.09996     11..... 64.4000........ 64.39995
    6..... 87.7000........ 87.69995     12..... 58.0000........ 57.99998
--------------------------------------------------------------------------------
LOCAL MINIMUM(S)=   56.29240
DAY NUMBER(S)/LAG      9/  18

LOCAL MAXIMUM(S)=   95.16785
DAY NUMBER(S)/LAG    205/  33

CRITICAL TEMPS  DAYS >  50.000  DAYS >  86.000  DAYS <  43.600      TD
NUMBER OF DAYS              365              108               0      .0
```

```
NAME=LAS VEGAS AF                              ID=
ALTITUDE= 2162M        LAT= 0  ON            LONG=  0  OW
----------------------------------------------------------------------
HARMONIC COMPONENTS
          ANGLE                 AMPLITUDE
 1 267.29791260              22.84041977
 2  10.50613022               2.42217827
 3 329.03637695                .19436756
 4 118.93275452                .44752240
 5 296.67590332                .43083024
 6 270.00000000                .01666641

  MEAN = 66.083328         VARIANCE = .00000
----------------------------------------------------------------------
INPUT DATA                                        (X SHIFT=13.5 DEGREES)
   MO.  INPUT TEMP  CALCULATED TEMP   MO.  INPUT TEMP  CALCULATED TEMP
    1..... 43.6000........ 43.59996    7..... 90.2000........ 90.19994
    2..... 48.3000........ 48.29997    8..... 87.7000........ 87.69997
    3..... 55.3000........ 55.29998    9..... 80.5000........ 80.49995
    4..... 65.0000........ 64.99995   10..... 67.1000........ 67.09998
    5..... 73.8000........ 73.79996   11..... 53.0000........ 52.99999
    6..... 83.4000........ 83.39993   12..... 45.1000........ 45.09998
----------------------------------------------------------------------
LOCAL MINIMUM(S)=   43.26268
DAY NUMBER(S)/LAG     6/  15

LOCAL MAXIMUM(S)=   90.35338
DAY NUMBER(S)/LAG   202/  30

CRITICAL TEMPS  DAYS >  50.000  DAYS >  86.000  DAYS <  43.600     TD
NUMBER OF DAYS              274              62              18     .0
```

```
NAME=BOULDER CITY                               ID=
ALTITUDE= 2525M        LAT= 0   ON         LONG=  0  OW
-----------------------------------------------------------------------
HARMONIC COMPONENTS
          ANGLE                AMPLITUDE
 1 265.70849609              21.29143143
 2   2.23390245               2.13781929
 3 336.80084229                .12693068
 4 139.74240112                .56740201
 5 284.72509766                .43246901
 6  90.00000000                .01666641

  MEAN = 66.933334        VARIANCE = .00000
-----------------------------------------------------------------------
INPUT DATA                                      (X SHIFT=13.5 DEGREES)
   MO.  INPUT TEMP  CALCULATED TEMP   MO.  INPUT TEMP  CALCULATED TEMP
    1..... 45.7000........ 45.69998     7..... 89.1000........ 89.09998
    2..... 49.6000........ 49.59998     8..... 86.9000........ 86.89996
    3..... 56.7000........ 56.69997     9..... 81.2000........ 81.19995
    4..... 65.6000........ 65.59998    10..... 68.8000........ 68.79996
    5..... 73.8000........ 73.79996    11..... 55.2000........ 55.19998
    6..... 82.7000........ 82.69995    12..... 47.9000........ 47.89997
-----------------------------------------------------------------------
LOCAL MINIMUM(S)=    45.63358
DAY NUMBER(S)/LAG     10/  19

LOCAL MAXIMUM(S)=    89.23752
DAY NUMBER(S)/LAG    202/  30

CRITICAL TEMPS  DAYS >  50.000  DAYS >  86.000  DAYS <  43.600      TD
NUMBER OF DAYS              290              55               0      .0
```

```
NAME=ADAVEN                                        ID=
ALTITUDE= 6250M          LAT= 0   ON              LONG=  0   OW
---------------------------------------------------------------------
HARMONIC COMPONENTS
          ANGLE                 AMPLITUDE
 1 262.38287354               19.91749954
 2  22.26380539                1.71561527
 3 220.60128784                 .61463404
 4 132.21621704                 .47257859
 5 279.10491943                 .46409833
 6      .00000000               .00000000

  MEAN = 48.599998          VARIANCE = .00000
---------------------------------------------------------------------
INPUT DATA                                          (X SHIFT=13.5 DEGREES)
   MO.   INPUT TEMP  CALCULATED TEMP    MO.   INPUT TEMP  CALCULATED TEMP
    1..... 29.0000........ 28.99999      7..... 70.2000........ 70.19995
    2..... 31.4000........ 31.39999      8..... 68.3000........ 68.29999
    3..... 37.7000........ 37.69997      9..... 61.8000........ 61.79998
    4..... 46.2000........ 46.19997     10..... 50.4000........ 50.39999
    5..... 53.8000........ 53.79998     11..... 39.1000........ 39.09999
    6..... 62.6000........ 62.59997     12..... 32.7000........ 32.69997
---------------------------------------------------------------------
LOCAL MINIMUM(S)=    28.94269
DAY NUMBER(S)/LAG     19/  28

LOCAL MAXIMUM(S)=    70.56773
DAY NUMBER(S)/LAG    205/  33

CRITICAL TEMPS  DAYS >  50.000  DAYS >  86.000  DAYS <  43.600      TD
NUMBER OF DAYS             169               0             157      .0
```

```
NAME=CALIENTE                                  ID=
ALTITUDE= 4402M          LAT= 0   ON          LONG=  0  OW
--------------------------------------------------------------------------------
HARMONIC COMPONENTS
          ANGLE                  AMPLITUDE
 1 267.08996582              21.51721954
 2   1.67440748               2.28150606
 3 253.88662720                .78066993
 4 124.71519470                .10137868
 5 267.51934814                .56105101
 6 270.00000000                .06666692

  MEAN = 53.116669         VARIANCE = .00000
--------------------------------------------------------------------------------
INPUT DATA                                             (X SHIFT=13.5 DEGREES)
   MO.  INPUT TEMP  CALCULATED TEMP    MO.  INPUT TEMP  CALCULATED TEMP
    1..... 30.4000........ 30.39999     7..... 76.0000........ 75.99995
    2..... 36.2000........ 36.19999     8..... 74.0000........ 73.99995
    3..... 43.8000........ 43.79998     9..... 66.2000........ 66.19997
    4..... 52.3000........ 52.29999    10..... 54.1000........ 54.09999
    5..... 60.3000........ 60.29998    11..... 41.6000........ 41.59999
    6..... 68.6000........ 68.59996    12..... 33.9000........ 33.89998
--------------------------------------------------------------------------------
LOCAL MINIMUM(S)=    30.33004
DAY NUMBER(S)/LAG     11/  20

LOCAL MAXIMUM(S)=    76.45648
DAY NUMBER(S)/LAG    206/  34

CRITICAL TEMPS  DAYS >  50.000  DAYS >  86.000  DAYS <  43.600      TD
NUMBER OF DAYS             199               0             127       .0
```

```
NAME=MINA                                     ID=
ALTITUDE= 4552M         LAT= 0   ON          LONG=  0  OW
----------------------------------------------------------------------
HARMONIC COMPONENTS
          ANGLE                AMPLITUDE
 1 266.45770264              21.91450882
 2  24.69316483               2.65303612
 3 251.99600220                .70099163
 4  79.97682190                .41466081
 5 257.55731201                .52297115
 6 270.00000000                .05833371

  MEAN = 53.691681        VARIANCE = .00000
----------------------------------------------------------------------
INPUT DATA                                         (X SHIFT=13.5 DEGREES)
   MO.   INPUT TEMP  CALCULATED TEMP    MO.   INPUT TEMP  CALCULATED TEMP
    1..... 32.1000........ 32.09999     7..... 78.2000........ 78.19997
    2..... 36.8000........ 36.80000     8..... 75.7000........ 75.69995
    3..... 43.3000........ 43.30000     9..... 66.5000........ 66.49997
    4..... 51.8000........ 51.79999    10..... 54.3000........ 54.30000
    5..... 60.3000........ 60.30000    11..... 41.4000........ 41.40000
    6..... 69.5000........ 69.49995    12..... 34.4000........ 34.39999
----------------------------------------------------------------------
LOCAL MINIMUM(S)=    31.99794
DAY NUMBER(S)/LAG     10/  19

LOCAL MAXIMUM(S)=    78.77864
DAY NUMBER(S)/LAG    206/  34

CRITICAL TEMPS  DAYS >  50.000  DAYS >  86.000  DAYS <  43.600      TD
NUMBER OF DAYS             197               0             129      .0
```

```
NAME=BOUSE,AZ                                  ID=
ALTITUDE=  930M        LAT= 0  ON          LONG=  0  OW
------------------------------------------------------------------------
HARMONIC COMPONENTS
          ANGLE                AMPLITUDE
 1 264.92681885             20.83792877
 2  16.79705429              2.97017288
 3 355.03057861               .38478243
 4  54.08358002               .56593013
 5 264.73260498               .26146865
 6  90.00000000               .04166730

  MEAN = 69.491684          VARIANCE = .00000
------------------------------------------------------------------------
INPUT DATA                                        (X SHIFT=13.5 DEGREES)
   MO.  INPUT TEMP  CALCULATED TEMP    MO.  INPUT TEMP  CALCULATED TEMP
    1..... 49.8000........ 49.80000     7..... 91.9000........ 91.89996
    2..... 54.1000........ 54.10000     8..... 90.7000........ 90.69998
    3..... 59.0000........ 58.99999     9..... 83.1000........ 83.09998
    4..... 66.8000........ 66.79997    10..... 71.3000........ 71.29999
    5..... 75.6000........ 75.59996    11..... 57.8000........ 57.80001
    6..... 84.1000........ 84.09998    12..... 49.7000........ 49.69999
------------------------------------------------------------------------
LOCAL MINIMUM(S)=    48.83789
DAY NUMBER(S)/LAG    363/   7

LOCAL MAXIMUM(S)=    92.64445
DAY NUMBER(S)/LAG    208/  36

CRITICAL TEMPS  DAYS >  50.000  DAYS >  86.000  DAYS <  43.600     TD
NUMBER OF DAYS              331              76               0     .0
```

```
NAME=EHRENBERG                                   ID=
ALTITUDE=  323M          LAT= 0  ON            LONG=  0  OW
--------------------------------------------------------------------------
HARMONIC COMPONENTS
          ANGLE                AMPLITUDE
 1 265.55664063              19.56842422
 2   3.59089708               2.66103935
 3  33.68999481                .30046356
 4  59.99943542                .34641039
 5 295.29754639                .50553501
 6 270.00000000                .04166602

  MEAN = 72.275009         VARIANCE = .00000
--------------------------------------------------------------------------
INPUT DATA                                         (X SHIFT=13.5 DEGREES)
   MO.  INPUT TEMP  CALCULATED TEMP    MO.  INPUT TEMP  CALCULATED TEMP
    1..... 52.9000........ 52.89999     7..... 92.5000........ 92.49995
    2..... 57.8000........ 57.80000     8..... 91.6000........ 91.59996
    3..... 62.5000........ 62.49999     9..... 85.8000........ 85.79997
    4..... 70.9000........ 70.89995    10..... 74.0000........ 73.99997
    5..... 78.5000........ 78.49997    11..... 61.2000........ 61.19999
    6..... 85.9000........ 85.89998    12..... 53.7000........ 53.69998
--------------------------------------------------------------------------
LOCAL MINIMUM(S)=    52.21143
DAY NUMBER(S)/LAG      2/  11

LOCAL MAXIMUM(S)=    92.99509
DAY NUMBER(S)/LAG    208/  36

CRITICAL TEMPS  DAYS >  50.000  DAYS >  86.000  DAYS <  43.600     TD
NUMBER OF DAYS             365             90               0     .0
```

```
NAME=KINGMAN                                        ID=
ALTITUDE= 3360M          LAT= 0   0N          LONG=  0   0W
-----------------------------------------------------------------------
HARMONIC COMPONENTS
          ANGLE                AMPLITUDE
 1 262.00781250              18.95625305
 2  21.50762177               1.95476604
 3 333.43463135                .33540964
 4  80.48406982                .52387500
 5 284.41088867                .54501402
 6  90.00000000                .00833448

  MEAN = 61.608337         VARIANCE = .00000
-----------------------------------------------------------------------
INPUT DATA                                      (X SHIFT=13.5 DEGREES)
   MO.  INPUT TEMP  CALCULATED TEMP    MO.  INPUT TEMP  CALCULATED TEMP
    1..... 43.4000........ 43.39998     7..... 82.3000........ 82.29997
    2..... 46.6000........ 46.59998     8..... 80.1000........ 80.09996
    3..... 50.6000........ 50.59998     9..... 74.4000........ 74.39996
    4..... 58.6000........ 58.59998    10..... 64.2000........ 64.19997
    5..... 66.6000........ 66.59998    11..... 52.4000........ 52.39999
    6..... 74.9000........ 74.89995    12..... 45.2000........ 45.19997
-----------------------------------------------------------------------
LOCAL MINIMUM(S)=    43.21735
DAY NUMBER(S)/LAG      8/  17

LOCAL MAXIMUM(S)=    82.58804
DAY NUMBER(S)/LAG    204/  32

CRITICAL TEMPS  DAYS >  50.000  DAYS >  86.000  DAYS <  43.600      TD
NUMBER OF DAYS              255               0              20      .0
```

```
NAME=KOFA     MTNS                              ID=
ALTITUDE= 1775M        LAT= 0   ON           LONG=  0  OW
-----------------------------------------------------------------
HARMONIC COMPONENTS
          ANGLE                AMPLITUDE
 1 261.73791504              17.76126099
 2   8.43195915               2.15954161
 3   2.40933744                .76739132
 4 103.43621826                .49693453
 5 310.49749756                .33719230
 6 270.00000000                .16666791

  MEAN = 72.866669         VARIANCE = .00000
-----------------------------------------------------------------
INPUT DATA                                     (X SHIFT=13.5 DEGREES)
   MO.  INPUT TEMP  CALCULATED TEMP    MO.  INPUT TEMP  CALCULATED TEMP
    1..... 55.7000........ 55.69997     7..... 91.3000........ 91.29996
    2..... 59.3000........ 59.29998     8..... 90.1000........ 90.09996
    3..... 62.9000........ 62.89998     9..... 85.6000........ 85.59998
    4..... 70.1000........ 70.09995    10..... 76.3000........ 76.29997
    5..... 76.9000........ 76.89993    11..... 63.8000........ 63.79998
    6..... 85.8000........ 85.79994    12..... 56.6000........ 56.59998
-----------------------------------------------------------------
LOCAL MINIMUM(S)=    55.23792
DAY NUMBER(S)/LAG      4/  13

LOCAL MAXIMUM(S)=    91.47470
DAY NUMBER(S)/LAG    204/  32

CRITICAL TEMPS   DAYS >   50.000   DAYS >   86.000   DAYS <   43.600      TD
NUMBER OF DAYS               365                89                 0      .0
```

```
NAME=QUARTZITE                                  ID=
ALTITUDE=  890M          LAT= 0  ON         LONG=  0  OW
-----------------------------------------------------------------------
HARMONIC COMPONENTS
          ANGLE                 AMPLITUDE
 1 265.90905762               21.38442612
 2   7.18257332                2.86593628
 3 335.77215576                1.09658599
 4  32.60964966                 .63399279
 5 261.82110596                 .17180488
 6  90.00000000                 .14166766

  MEAN = 72.008347          VARIANCE = .00000
-----------------------------------------------------------------------
INPUT DATA                                          (X SHIFT=13.5 DEGREES)
   MO.  INPUT TEMP  CALCULATED TEMP   MO.  INPUT TEMP  CALCULATED TEMP
    1..... 50.9000........ 50.89999     7..... 94.8000........ 94.79997
    2..... 56.7000........ 56.69999     8..... 92.9000........ 92.89998
    3..... 62.2000........ 62.19998     9..... 85.4000........ 85.39996
    4..... 69.3000........ 69.29999    10..... 74.4000........ 74.39996
    5..... 78.8000........ 78.79996    11..... 60.8000........ 60.80000
    6..... 87.5000........ 87.49995    12..... 50.4000........ 50.40000
-----------------------------------------------------------------------
LOCAL MINIMUM(S)=    49.31496
DAY NUMBER(S)/LAG    362/   6

LOCAL MAXIMUM(S)=    95.29239
DAY NUMBER(S)/LAG    206/  34

CRITICAL TEMPS  DAYS >  50.000  DAYS >  86.000  DAYS <  43.600      TD
NUMBER OF DAYS             343             94                0      .0
```

```
NAME=BARSTOW                                  ID=
ALTITUDE= 2160M        LAT= 0   ON         LONG=  0  OW
------------------------------------------------------------------------
HARMONIC COMPONENTS
          ANGLE                AMPLITUDE
 1 266.19616699              19.27663803
 2  14.70465660               2.79050732
 3   4.57352448                .41799861
 4 117.12570190                .66478765
 5 308.39019775                .63684928
 6  90.00000000                .04166730

  MEAN = 64.558334          VARIANCE = .00000
------------------------------------------------------------------------
INPUT DATA                                        (X SHIFT=13.5 DEGREES)
   MO.  INPUT TEMP  CALCULATED TEMP   MO.  INPUT TEMP  CALCULATED TEMP
    1..... 46.2000........ 46.19997    7..... 85.6000........ 85.59996
    2..... 50.4000........ 50.39998    8..... 82.9000........ 82.89996
    3..... 55.2000........ 55.19997    9..... 77.9000........ 77.89996
    4..... 63.1000........ 63.09997   10..... 65.7000........ 65.69997
    5..... 69.8000........ 69.79997   11..... 52.9000........ 52.89999
    6..... 78.7000........ 78.69997   12..... 46.3000........ 46.29998
------------------------------------------------------------------------
LOCAL MINIMUM(S)=    45.35085
DAY NUMBER(S)/LAG    365/   9

LOCAL MAXIMUM(S)=    85.65652
DAY NUMBER(S)/LAG    200/  28

CRITICAL TEMPS  DAYS >  50.000  DAYS >  86.000  DAYS <  43.600      TD
NUMBER OF DAYS             287               0               0      .0
```

NAME=DAGGETT FAA AP ID=
ALTITUDE= 1915M LAT= 0 ON LONG= 0 OW

HARMONIC COMPONENTS

	ANGLE	AMPLITUDE
1	265.27008057	19.59075928
2	13.59892082	2.65816307
3	15.64217186	.43269271
4	122.11056519	.67884541
5	297.67114258	.49978292
6	90.00000000	.00000064

MEAN = 66.650009 VARIANCE = .00000

INPUT DATA (X SHIFT=13.5 DEGREES)

MO.	INPUT TEMP	CALCULATED TEMP	MO.	INPUT TEMP	CALCULATED TEMP
1	48.0000	47.99998	7	87.7000	87.69997
2	51.8000	51.79999	8	85.4000	85.39995
3	56.9000	56.89999	9	80.3000	80.29996
4	64.8000	64.79997	10	68.4000	68.39996
5	72.0000	71.99995	11	55.0000	55.00000
6	81.0000	80.99995	12	48.5000	48.49998

LOCAL MINIMUM(S)= 47.48762
DAY NUMBER(S)/LAG 2/ 11

LOCAL MAXIMUM(S)= 87.80585
DAY NUMBER(S)/LAG 202/ 30

CRITICAL TEMPS	DAYS > 50.000	DAYS > 86.000	DAYS < 43.600	TD
NUMBER OF DAYS	306	39	0	.0

```
NAME=DEEP SPRINGS                                ID=
ALTITUDE= 5223M         LAT= 0   ON         LONG=  0  OW
-----------------------------------------------------------------------
HARMONIC COMPONENTS
         ANGLE                 AMPLITUDE
 1 266.55578613           20.93473816
 2   2.50784063            2.09490252
 3 299.05456543             .85797167
 4 176.15911865             .62204659
 5 308.18768311             .76727569
 6 270.00000000             .21666652

  MEAN = 52.833336        VARIANCE = .00000
-----------------------------------------------------------------------
INPUT DATA                                    (X SHIFT=13.5 DEGREES)
   MO.  INPUT TEMP  CALCULATED TEMP   MO.  INPUT TEMP  CALCULATED TEMP
    1..... 30.5000........ 30.49999    7..... 75.0000........ 74.99995
    2..... 36.8000........ 36.79999    8..... 71.9000........ 71.89996
    3..... 43.4000........ 43.39999    9..... 66.4000........ 66.39996
    4..... 51.8000........ 51.79998   10..... 54.2000........ 54.19998
    5..... 58.7000........ 58.69998   11..... 41.7000........ 41.70000
    6..... 69.4000........ 69.39996   12..... 34.2000........ 34.19999
-----------------------------------------------------------------------
LOCAL MINIMUM(S)=    30.33567
DAY NUMBER(S)/LAG     10/  19

LOCAL MAXIMUM(S)=    75.00586
DAY NUMBER(S)/LAG    196/  24

CRITICAL TEMPS  DAYS >  50.000  DAYS >  86.000  DAYS <  43.600      TD
NUMBER OF DAYS             198               0              129      .0
```

```
NAME=INYOKERN                                   ID=
ALTITUDE= 2440M         LAT= 0   ON            LONG=   0  OW
---------------------------------------------------------------------
HARMONIC COMPONENTS
          ANGLE               AMPLITUDE
 1 265.62994385            19.59708405
 2  19.10655212             2.44404078
 3 354.68530273              .71976101
 4 133.89758301              .62449956
 5 301.45135498              .40232897
 6 270.00000000              .02500025

  MEAN = 63.625000        VARIANCE = .00000
---------------------------------------------------------------------
INPUT DATA                                   (X SHIFT=13.5 DEGREES)
   MO.  INPUT TEMP  CALCULATED TEMP    MO.  INPUT TEMP  CALCULATED TEMP
    1..... 44.9000........ 44.89998    7..... 84.8000........ 84.79996
    2..... 48.9000........ 48.89997    8..... 82.0000........ 81.99995
    3..... 54.0000........ 53.99998    9..... 76.7000........ 76.69995
    4..... 61.3000........ 61.29998   10..... 65.3000........ 65.29997
    5..... 69.0000........ 68.99995   11..... 52.2000........ 52.19999
    6..... 78.9000........ 78.89996   12..... 45.5000........ 45.49998
---------------------------------------------------------------------
LOCAL MINIMUM(S)=    44.40099
DAY NUMBER(S)/LAG      2/  11

LOCAL MAXIMUM(S)=    84.81850
DAY NUMBER(S)/LAG    199/  27

CRITICAL TEMPS  DAYS >  50.000  DAYS >  86.000  DAYS <  43.600      TD
NUMBER OF DAYS             274               0               0      .0
```

```
NAME=IRON MOUNTAIN                                 ID=
ALTITUDE=   922M          LAT= 0   ON          LONG=   0   OW
--------------------------------------------------------------------------------
HARMONIC COMPONENTS
          ANGLE                 AMPLITUDE
 1 264.43383789               20.70796585
 2   4.47256374                2.24406624
 3  11.30972290                 .50990391
 4 137.36621094                 .72591138
 5 306.21405029                 .60691857
 6 270.00000000                 .05000177

  MEAN = 73.583328          VARIANCE = .00000
--------------------------------------------------------------------------------
INPUT DATA                                            (X SHIFT=13.5 DEGREES)
   MO.   INPUT TEMP   CALCULATED TEMP    MO.   INPUT TEMP   CALCULATED TEMP
    1..... 53.2000........ 53.19997       7..... 95.2000........ 95.19995
    2..... 57.2000........ 57.19997       8..... 92.7000........ 92.69994
    3..... 62.9000........ 62.89998       9..... 88.3000........ 88.29996
    4..... 71.8000........ 71.79994      10..... 76.1000........ 76.09995
    5..... 79.4000........ 79.39993      11..... 62.2000........ 62.19999
    6..... 89.1000........ 89.09995      12..... 54.9000........ 54.89998
--------------------------------------------------------------------------------
LOCAL MINIMUM(S)=     52.95314
DAY NUMBER(S)/LAG       7/  16

LOCAL MAXIMUM(S)=     95.21440
DAY NUMBER(S)/LAG     199/  27

CRITICAL TEMPS   DAYS >   50.000   DAYS >   86.000   DAYS <   43.600       TD
NUMBER OF DAYS                365               109                0       .0
```

```
NAME=LANCASTER                                  ID=
ALTITUDE= 2340M          LAT= 0   ON          LONG=  0   OW
-----------------------------------------------------------------------
HARMONIC COMPONENTS
          ANGLE                AMPLITUDE
 1 264.83410645              18.79236221
 2  18.61288834               2.92422581
 3   9.46218872                .40551853
 4 104.46493530                .80897748
 5 295.80444336                .55608439
 6  90.00000000                .11666869

  MEAN = 61.116676         VARIANCE = .00000
-----------------------------------------------------------------------
INPUT DATA                                         (X SHIFT=13.5 DEGREES)
   MO.  INPUT TEMP  CALCULATED TEMP   MO.  INPUT TEMP  CALCULATED TEMP
    1..... 43.8000........ 43.79999    7..... 82.1000........ 82.09995
    2..... 47.2000........ 47.19998    8..... 79.4000........ 79.39996
    3..... 51.6000........ 51.59998    9..... 74.3000........ 74.29997
    4..... 59.0000........ 58.99999   10..... 62.7000........ 62.70000
    5..... 65.8000........ 65.79996   11..... 49.8000........ 49.80000
    6..... 74.3000........ 74.29999   12..... 43.4000........ 43.40000
-----------------------------------------------------------------------
LOCAL MINIMUM(S)=    42.83802
DAY NUMBER(S)/LAG    362/    6

LOCAL MAXIMUM(S)=    82.26154
DAY NUMBER(S)/LAG    202/   30

CRITICAL TEMPS  DAYS >  50.000  DAYS >  86.000  DAYS <  43.600      TD
NUMBER OF DAYS             252               0              30      .0
```

```
NAME=LUCERNE VALLEY                          ID=
ALTITUDE=    0M         LAT= 0   0N         LONG=  0  0W
----------------------------------------------------------------------
HARMONIC COMPONENTS
          ANGLE                 AMPLITUDE
 1 265.72863770              18.94632339
 2  24.18244934               2.56320190
 3 322.12481689                .19003117
 4 118.67698669                .72187912
 5 278.91540527                .39439255
 6  90.00000000                .04999923

  MEAN = 60.566658        VARIANCE = .00000
----------------------------------------------------------------------
INPUT DATA                                          (X SHIFT=13.5 DEGREES)
   MO.  INPUT TEMP  CALCULATED TEMP   MO.  INPUT TEMP  CALCULATED TEMP
    1..... 42.9000........ 42.89997    7..... 81.7000........ 81.69994
    2..... 45.9000........ 45.89996    8..... 79.0000........ 78.99995
    3..... 51.3000........ 51.29997    9..... 72.9000........ 72.89995
    4..... 58.6000........ 58.59998   10..... 61.6000........ 61.59998
    5..... 65.7000........ 65.69995   11..... 49.2000........ 49.19997
    6..... 74.5000........ 74.49994   12..... 43.5000........ 43.49997
----------------------------------------------------------------------
LOCAL MINIMUM(S)=    42.65036
DAY NUMBER(S)/LAG      4/  13

LOCAL MAXIMUM(S)=    81.87198
DAY NUMBER(S)/LAG    202/  30

CRITICAL TEMPS   DAYS >  50.000   DAYS >  86.000   DAYS <  43.600      TD
NUMBER OF DAYS               247                0               42      .0
```

NAME=MECCA 3 SE ID=

ALTITUDE= -180M LAT= 0 0N LONG= 0 0W

HARMONIC COMPONENTS

	ANGLE	AMPLITUDE
1	263.80889893	18.03822327
2	351.88671875	2.36190844
3	9.09009361	.42196959
4	125.62957764	.59465182
5	285.51257324	.60571277
6	90.00000000	.05833498

MEAN = 72.141678 VARIANCE = .00000

INPUT DATA (X SHIFT=13.5 DEGREES)

MO.	INPUT TEMP	CALCULATED TEMP	MO.	INPUT TEMP	CALCULATED TEMP
1.....	53.9000........	53.89999	7.....	90.8000........	90.79996
2.....	57.9000........	57.89999	8.....	88.9000........	88.89996
3.....	63.3000........	63.29999	9.....	85.6000........	85.59998
4.....	70.7000........	70.69995	10.....	75.1000........	75.09996
5.....	77.3000........	77.29999	11.....	62.3000........	62.30000
6.....	84.5000........	84.49992	12.....	55.4000........	55.39999

LOCAL MINIMUM(S)= 53.66209

DAY NUMBER(S)/LAG 7/ 16

LOCAL MAXIMUM(S)= 90.92863

DAY NUMBER(S)/LAG 202/ 30

CRITICAL TEMPS	DAYS > 50.000	DAYS > 86.000	DAYS < 43.600	TD
NUMBER OF DAYS	365	84	0	.0

```
NAME=NEEDLES                                        ID=
ALTITUDE=  480M          LAT= 0  ON           LONG=  0  OW
-----------------------------------------------------------------------------
HARMONIC COMPONENTS
          ANGLE                AMPLITUDE
 1 265.69256592              21.58928680
 2  12.88529778               2.35425282
 3  25.90642929                .64850330
 4 140.84683228                .72590625
 5 299.25317383                .52153778
 6 270.00000000                .04999986

  MEAN = 72.666672          VARIANCE = .00000
-----------------------------------------------------------------------------
INPUT DATA                                          (X SHIFT=13.5 DEGREES)
   MO.  INPUT TEMP  CALCULATED TEMP   MO.  INPUT TEMP  CALCULATED TEMP
    1..... 51.9000........ 51.89998    7..... 95.3000........ 95.29997
    2..... 55.9000........ 55.89999    8..... 92.6000........ 92.59996
    3..... 61.7000........ 61.69997    9..... 87.5000........ 87.49997
    4..... 70.7000........ 70.69995   10..... 74.6000........ 74.59998
    5..... 79.3000........ 79.29996   11..... 60.0000........ 59.99999
    6..... 89.4000........ 89.39993   12..... 53.1000........ 53.09998
-----------------------------------------------------------------------------
LOCAL MINIMUM(S)=    51.60561
DAY NUMBER(S)/LAG      6/  15

LOCAL MAXIMUM(S)=    95.31104
DAY NUMBER(S)/LAG    199/  27

CRITICAL TEMPS   DAYS >  50.000  DAYS >  86.000  DAYS <  43.600      TD
NUMBER OF DAYS              365             106               0      .0
```

```
NAME=RANDSBURG                                  ID=
ALTITUDE= 3570M          LAT= 0   ON          LONG=  0  OW
----------------------------------------------------------------------
HARMONIC COMPONENTS
          ANGLE                 AMPLITUDE
 1 262.09857178               19.35017776
 2  22.30445862                2.37135649
 3 347.00561523                 .22236094
 4 127.15371704                 .66916049
 5 289.68981934                 .67287052
 6 270.00000000                 .04999986

  MEAN = 62.966675         VARIANCE = .00000
----------------------------------------------------------------------
INPUT DATA                                        (X SHIFT=13.5 DEGREES)
   MO.  INPUT TEMP  CALCULATED TEMP   MO.  INPUT TEMP  CALCULATED TEMP
    1..... 44.5000........ 44.49999    7..... 84.2000........ 84.19995
    2..... 47.7000........ 47.69998    8..... 81.8000........ 81.79996
    3..... 52.1000........ 52.09998    9..... 76.8000........ 76.79999
    4..... 60.0000........ 59.99999   10..... 65.3000........ 65.29996
    5..... 67.3000........ 67.29997   11..... 52.6000........ 52.59999
    6..... 76.7000........ 76.69995   12..... 46.6000........ 46.59999
----------------------------------------------------------------------
LOCAL MINIMUM(S)=    44.43033
DAY NUMBER(S)/LAG     10/  19

LOCAL MAXIMUM(S)=    84.34979
DAY NUMBER(S)/LAG    202/  30

CRITICAL TEMPS  DAYS >  50.000  DAYS >  86.000  DAYS <  43.600      TD
NUMBER OF DAYS              267               0               0      .0
```

```
NAME=THERMAL FAA AF                           ID=
ALTITUDE= -112M         LAT= 0   0N         LONG=  0  0W
---------------------------------------------------------------------
HARMONIC COMPONENTS
         ANGLE                 AMPLITUDE
 1 265.04815674              18.88204193
 2   2.04110050               2.33975172
 3  28.17840958                .52941346
 4 129.18280029                .73105347
 5 294.60125732                .59218788
 6 270.00000000                .00833257

  MEAN = 73.058334          VARIANCE = .00000
---------------------------------------------------------------------
INPUT DATA                                      (X SHIFT=13.5 DEGREES)
   MO.  INPUT TEMP  CALCULATED TEMP   MO.  INPUT TEMP  CALCULATED TEMP
    1..... 54.6000........ 54.59997    7..... 92.8000........ 92.79994
    2..... 58.4000........ 58.39998    8..... 90.5000........ 90.49995
    3..... 63.6000........ 63.59996    9..... 86.7000........ 86.69994
    4..... 71.7000........ 71.69995   10..... 75.4000........ 75.39995
    5..... 78.6000........ 78.59996   11..... 62.0000........ 61.99998
    6..... 86.8000........ 86.79997   12..... 55.6000........ 55.59998
---------------------------------------------------------------------
LOCAL MINIMUM(S)=    54.26907
DAY NUMBER(S)/LAG      5/  14

LOCAL MAXIMUM(S)=    92.84366
DAY NUMBER(S)/LAG    200/  28

CRITICAL TEMPS   DAYS >. 50.000  DAYS >  86.000  DAYS <  43.600      TD
NUMBER OF DAYS               365              97               0      .0
```

```
NAME=TWENTYNINE PALMS                          ID=
ALTITUDE= 1975M          LAT= 0   ON          LONG=  0  OW
------------------------------------------------------------------------
HARMONIC COMPONENTS
          ANGLE                AMPLITUDE
 1 264.91314697              19.61573410
 2  13.78639984               2.37790537
 3   9.46253395                .40551895
 4 123.00434875                .63595951
 5 308.38781738                .54628038
 6 270.00000000                .06666563

  MEAN = 68.266678          VARIANCE = .00000
------------------------------------------------------------------------
INPUT DATA                                           (X SHIFT=13.5 DEGREES)
   MO.   INPUT TEMP  CALCULATED TEMP    MO.   INPUT TEMP  CALCULATED TEMP
    1..... 49.4000........ 49.39999      7..... 89.2000........ 89.19995
    2..... 53.2000........ 53.19998      8..... 86.9000........ 86.89995
    3..... 58.1000........ 58.09998      9..... 81.8000........ 81.79999
    4..... 66.5000........ 66.49995     10..... 70.1000........ 70.09998
    5..... 73.6000........ 73.59998     11..... 57.1000........ 57.10000
    6..... 82.9000........ 82.89995     12..... 50.4000........ 50.39999
------------------------------------------------------------------------
LOCAL MINIMUM(S)=    48.98969
DAY NUMBER(S)/LAG      4/  13

LOCAL MAXIMUM(S)=    89.25717
DAY NUMBER(S)/LAG    201/  29

CRITICAL TEMPS  DAYS >  50.000  DAYS >  86.000  DAYS <  43.600      TD
NUMBER OF DAYS              331              58               0      .0
```

```
NAME=VICTORVILLE                           ID=
ALTITUDE= 2858M         LAT= 0  ON        LONG=  0  OW
----------------------------------------------------------------------
HARMONIC COMPONENTS
          ANGLE                AMPLITUDE
 1 261.72955322              17.78585052
 2  17.32278824               2.63080072
 3   8.12915230                .23570153
 4 118.67678833                .72187924
 5 296.61407471                .53962660
 6  90.00000000                .01666641

  MEAN = 60.116676         VARIANCE = .00000
----------------------------------------------------------------------
INPUT DATA                                      (X SHIFT=13.5 DEGREES)
   MO.   INPUT TEMP  CALCULATED TEMP   MO.  INPUT TEMP  CALCULATED TEMP
    1..... 43.5000........ 43.49999    7..... 79.6000........ 79.59996
    2..... 46.3000........ 46.30000    8..... 77.8000........ 77.79997
    3..... 50.4000........ 50.39999    9..... 73.4000........ 73.39998
    4..... 57.4000........ 57.39999   10..... 62.5000........ 62.50000
    5..... 63.6000........ 63.59997   11..... 50.3000........ 50.30000
    6..... 72.2000........ 72.19995   12..... 44.4000........ 44.39999
----------------------------------------------------------------------
LOCAL MINIMUM(S)=   43.23757
DAY NUMBER(S)/LAG     5/  14

LOCAL MAXIMUM(S)=   79.82062
DAY NUMBER(S)/LAG   203/  31

CRITICAL TEMPS  DAYS >  50.000  DAYS >  86.000  DAYS <  43.600      TD
NUMBER OF DAYS             246               0              23      .0
```

Appendix C

Following are the wind data summaries for all stations located within the CDCA. These data were used to construct the wind roses displayed in Figure 23 Included are summaries for the stations listed below; several stations have only a limited record length.

Apple Valley
Bishop
Blythe
China Lake
Daggett
Desert Center
Edwards AFB
El Centro
George AFB
Indio
Lancaster
Mojave
Needles
Nellis AFB, NV
Palmdale
Palm Springs
Rice
Sandberg
Silver Lake
Thermal
Twentynine Palms
Yuma, AZ

Source: Wind in California
State of California
The Resources Agency
Department of Water Resources
Bulletin No. 185
January 1978

SURFACE WINDS

PERCENTAGE FREQUENCY OF WIND
DIRECTION AND SPEED
(FROM HOURLY OBSERVATIONS)

STATION:

STATION NAME: Apple Valley, California

YEARS: December 1960 thru November 1965

MONTH: ALL

CLASS: ALL WEATHER

HOURS (L.S.T.): ALL

LOCATION: 34° 32', 117° 13', 2,930'

HEIGHT ABOVE GROUND:

SPEED MPH DIR.	1-3	4-6	7-10	11-16	17-27	28-40	>40					%	MEAN WIND SPEED
N	0.0	0.7	1.1	0.4	0.1	0.0						2.3	
NNE	0.0	0.4	1.0	0.8	0.2	0.0						2.5	
NE	0.0	0.3	0.5	0.4	0.1							1.3	
ENE		0.2	0.4	0.3	0.0							1.0	
E		0.3	0.4	0.2	0.0							0.9	
ESE	0.0	0.1	0.2	0.1	0.0							0.5	
SE		0.1	0.1	0.0	0.0	0.0						0.3	
SSE	0.0	0.3	0.5	0.5	0.1							1.4	
S	0.0	0.5	3.1	6.0	2.1	0.1						11.7	
SSW	0.0	0.6	4.4	6.8	2.0	0.0						13.8	
SW	0.0	0.7	2.0	1.6	0.3	0.0						4.5	
WSW	0.0	1.4	2.3	1.6	0.6	0.0						5.9	
W	0.0	1.6	2.3	1.8	1.0	0.0						6.7	
WNW	0.0	0.5	0.9	0.6	0.3	0.0						2.4	
NW		0.3	0.4	0.1	0.0							0.9	
NNW	0.0	0.5	0.6	0.2	0.0	0.0						1.4	
CALM												42.5	
42.5	0.1	8.7	20.5	21.3	6.8	0.2						100.0	

DATA FROM NATIONAL CLIMATIC CENTER
FEDERAL BUILDING – ASHEVILLE, N.C., 28801

TOTAL NUMBER OF OBSERVATIONS 27,982

SURFACE WINDS

PERCENTAGE FREQUENCY OF WIND
DIRECTION AND SPEED
(FROM HOURLY OBSERVATIONS)

STATION: 23157 | STATION NAME: BISHOP APT CALIF | YEARS: 48-72 | MONTH: ALL

CLASS: ALL WEATHER | HOURS (L.S.T.): ALL

LOCATION: 37°22', 118°22', 4145'

HEIGHT ABOVE GROUND: 40' before Dec. 1964, 20' after

SPEED (KNTS) DIR.	1-3	4-6	7-10	11-16	17-21	22-27	28-33	34-40	41-47	48-55	≥56	%	MEAN WIND SPEED
N	1.7	4.1	2.7	3.4	1.6	.6	.1	.0	.0			14.3	10.0
NNE	.8	1.3	.9	1.3	.5	.2	.0	.0				4.9	9.5
NE	.5	1.2	.5	.2	.1	.0	.0					2.8	5.9
ENE	.3	.4	.1	.0	.0							.9	4.7
E	.6	.6	.2	.0	.0							1.4	4.7
ESE	.3	.5	.2	.0	.0	.0	.0					1.0	5.4
SE	.7	1.0	.5	.6	.1	.0	.0					3.3	7.6
SSE	.5	1.5	2.4	2.9	.8	.2	.0					8.3	10.5
S	1.0	3.3	4.0	3.8	1.0	.2	.0	.0				13.2	9.6
SSW	.5	1.7	1.4	1.0	.1	.0	.0					4.8	7.9
SW	.9	2.0	1.1	.5	.1	.0	.0	.0				4.6	6.5
WSW	.4	1.2	.6	.4	.1	.0	.0	.0				2.8	7.5
W	.8	2.0	1.2	.7	.2	.0	.0	.0				5.0	7.3
WNW	.7	2.1	1.3	.4	.1	.0						4.6	6.7
NW	1.8	5.7	3.0	.9	.2	.0	.0					11.7	6.4
NNW	1.3	3.8	1.9	1.1	.3	.1	.0	.0				8.6	7.3
CALM												7.9	
7.9	13.3	32.2	22.4	17.4	5.1	1.5	.2	.0	.0			100.0	7.5

DATA FROM NATIONAL CLIMATIC CENTER
FEDERAL BUILDING – ASHEVILLE N.C. 28801

TOTAL NUMBER OF OBSERVATIONS 109147

SURFACE WINDS

PERCENTAGE FREQUENCY OF WIND
DIRECTION AND SPEED
(FROM HOURLY OBSERVATIONS)

23158 — STATION | Blythe, Calif. — STATION NAME | 1969 thru 1974 — YEARS | ALL — MONTH

ALL WEATHER — CLASS | ALL — HOURS (L.S.T.)

33° 37', 114° 43', 394' — LOCATION

HEIGHT ABOVE GROUND

SPEED MPH / DIR.	1-3	4-6	7-10	11-16	17-21	>21						%	MEAN WIND SPEED
N	0.2	3.9	2.9	2.3	0.7	0.2						10.3	9.2
NNE	0.1	1.3	0.7	0.3	0.1	0.0						2.4	7.2
NE	0.1	1.0	0.4	0.1	0.0	0.0						1.6	6.6
ENE	0.1	1.0	0.4	0.1	0.0	0.0						1.6	6.3
E	0.2	1.8	0.7	0.1	0.0	0.0						2.7	5.9
ESE	0.1	1.4	0.7	0.1	0.0	0.0						2.3	6.3
SE	0.1	1.7	1.3	0.3	0.0							3.5	7.0
SSE	0.1	1.9	2.4	1.4	0.2	0.0						5.9	8.6
S	0.2	3.7	6.2	5.3	0.7	0.1						16.2	9.7
SSW	0.1	1.8	2.0	1.6	0.3	0.0						5.8	9.3
SW	0.1	1.9	2.0	1.6	0.5	0.1						6.3	9.7
WSW	0.1	2.4	2.4	1.4	0.5	0.1						6.9	9.0
W	0.2	2.5	1.7	0.6	0.1	0.0						5.1	7.3
WNW	0.1	1.4	0.6	0.2	0.0	0.0						2.4	6.7
NW	0.1	2.1	1.3	0.6	0.2	0.1						4.4	7.9
NNW	0.2	2.8	2.1	1.6	0.5	0.2						7.3	9.2
Avg.	2.9	5.0	8.4	13.3	18.5	24.6							
CALM												15.4	7.3
15,4	2.1	32.5	27.8	17.5	3.8	0.7						100.0	

DATA FROM NATIONAL CLIMATIC CENTER
FEDERAL BUILDING – ASHEVILLE, N.C., 28801

TOTAL NUMBER OF OBSERVATIONS 43800

SURFACE WINDS

PERCENTAGE FREQUENCY OF WIND
DIRECTION AND SPEED
(FROM HOURLY OBSERVATIONS)

93104 — STATION
CHINA LAKE, CALIF/INYOKERN NWSED — STATION NAME
45-72 — YEARS
ALL — MONTH
ALL WEATHER — CLASS
ALL — HOURS (L.S.T.)
35°41', 117°41', 2238' — LOCATION
18' — HEIGHT ABOVE GROUND

SPEED (KNTS) DIR.	1-3	4-6	7-10	11-16	17-21	22-27	28-33	34-40	41-47	48-55	≥56	%	MEAN WIND SPEED
N	.8	.6	.4	.4	.3	.2	.0	.0	.0			2.8	9.3
NNE	.4	.3	.1	.1	.1	.0	.0	.0				1.0	7.4
NE	.6	.6	.2	.1	.0	.0	.0					1.5	4.7
ENE	.4	.3	.1	.0	.0	.0						.8	4.5
E	1.2	1.7	.8	.2	.0	.0	.0	.0				3.9	5.3
ESE	.6	1.1	.6	.1	.0	.0	.0					2.4	5.7
SE	1.2	2.1	1.3	.3	.0	.0	.0	.0				5.0	5.8
SSE	.6	1.1	.7	.2	.1	.0	.0	.0				2.8	6.4
S	1.5	2.6	2.5	2.0	1.0	.4	.1	.0	.0			10.3	9.6
SSW	.8	1.7	2.3	2.3	1.0	.5	.1	.0	.0	.0		8.7	10.9
SW	1.8	3.9	4.4	3.3	1.6	1.0	.3	.1	.0	.0		16.4	10.5
WSW	1.0	1.7	1.6	1.1	.7	.6	.2	.1	.0	.0	.0	6.9	10.8
W	1.7	2.5	1.7	1.4	.9	.5	.2	.1	.0	.0	.0	8.9	9.7
WNW	.5	.6	.4	.4	.2	.1	.0	.0	.0	.0		2.3	9.1
NW	.8	1.0	.6	.5	.2	.1	.0	.0	.0			3.2	7.7
NNW	.4	.4	.3	.3	.1	.1	.0	.0	.0	.0		1.6	9.3
CALM												21.5	
21.5	14.3	22.3	18.1	12.8	6.2	3.5	1.1	.3	.0	.0	.0	100.0	7.1

DATA FROM NATIONAL CLIMATIC CENTER
FEDERAL BUILDING - ASHEVILLE, N.C., 28801

TOTAL NUMBER OF OBSERVATIONS 207031

SURFACE WINDS

PERCENTAGE FREQUENCY OF WIND
DIRECTION AND SPEED
(FROM HOURLY OBSERVATIONS)

23161 — STATION | Daggett, CA FAA — STATION NAME | 1955 - 1964 — YEARS | ALL — MONTH

ALL WEATHER — CLASS | ALL — HOURS (L.S.T.)

34 52', 116 47', 1,929' — LOCATION

HEIGHT ABOVE GROUND

SPEED MPH DIR.	1-3	4-6	7-10	11-16	17-21	> 21						%	MEAN WIND SPEED
N	0.1	0.6	0.5	0.2	0.0	0.0						1.4	7.5
NNE	0.1	0.4	0.4	0.2	0.1	0.0						1.2	8.5
NE	0.1	1.0	1.0	0.2	0.0							2.4	7.4
ENE	0.1	0.7	0.9	0.3	0.0	0.0						1.9	7.7
E	0.1	1.3	1.6	0.6	0.1	0.0						3.7	8.0
ESE	0.1	0.7	0.7	0.3	0.1	0.0						1.9	8.1
SE	0.1	0.8	0.4	0.1	0.0	0.0						1.4	6.7
SSE	0.0	0.3	0.1	0.0	0.0	0.0						0.5	6.8
S	0.0	0.3	0.1	0.0	0.0	0.0						0.6	6.9
SSW	0.0	0.2	0.1	0.1	0.1	0.0						0.5	9.9
SW	0.1	0.5	0.6	0.8	1.0	0.4						3.3	14.1
WSW	0.1	0.9	2.1	3.4	3.8	1.3						11.6	15.1
W	0.1	2.7	8.7	6.3	3.3	1.4						22.5	12.1
WNW	0.1	3.2	11.0	8.1	2.0	0.5						24.9	10.8
NW	0.1	1.9	4.2	2.2	0.2	0.0						8.6	9.2
NNW	0.1	0.6	0.7	0.3	0.0	0.0						1.7	8.0
Avg.	2.8	5.1	8.8	13.0	18.8	25.0							
CALM												11.8	9.8
11.8	1.3	16.0	33.4	23.0	10.8	3.7						100.0	

DATA FROM NATIONAL CLIMATIC CENTER
FEDERAL BUILDING – ASHEVILLE, N.C., 28801

TOTAL NUMBER OF OBSERVATIONS 87,556

SURFACE WINDS

PERCENTAGE FREQUENCY OF WIND
DIRECTION AND SPEED
(FROM HOURLY OBSERVATIONS)

STATION: ______ STATION NAME: Desert Center, California AAF YEARS: June 1943 thru March 1944 MONTH: ALL

CLASS: ALL WEATHER HOURS (L.S.T.): ALL

LOCATION: 33° 45', 115° 20', 541'

HEIGHT ABOVE GROUND: ______

SPEED MPH / DIR.	1-3	4-12	13-24	25-31	32-46	>47						%	MEAN WIND SPEED
N	0.4	1.5	0.1									2.0	6.4
NNE	0.4	1.5	0.2		0.0							2.1	6.7
NE	0.5	2.1	0.2	0.0	0.0							2.8	6.8
ENE	0.9	3.1	0.3	0.0								4.3	6.6
E	0.9	4.5	0.3		0.1							5.7	6.7
ESE	0.6	4.5	0.9	0.0								6.1	8.2
SE	0.6	2.4	0.3	0.0								3.4	6.5
SSE	0.5	1.8	0.3									2.7	7.2
S	0.7	1.7	0.2	0.0								2.6	6.0
SSW	0.5	2.2	0.6	0.0								3.3	6.1
SW	0.5	1.7	0.5	0.0								2.7	7.6
WSW	1.2	8.1	2.5	0.1								11.8	8.0
W	2.0	18.7	0.9									21.5	6.8
WNW	1.5	12.3	0.4	0.0								14.2	6.9
NW	0.6	5.5	1.8	0.1								8.0	9.7
NNW	0.5	3.3	1.5	0.0								5.4	9.6
												1.4	
CALM													7.5
1.4	12.3	74.8	11.0	0.4	0.1							100.0	

DATA FROM NATIONAL CLIMATIC CENTER
FEDERAL BUILDING – ASHEVILLE, N.C., 28801

TOTAL NUMBER OF OBSERVATIONS 6,669

SURFACE WINDS

PERCENTAGE FREQUENCY OF WIND
DIRECTION AND SPEED
(FROM HOURLY OBSERVATIONS)

STATION	STATION NAME	YEARS	MONTH
23114	EDWARDS AFB CALIFORNIA	62-72	ALL

CLASS: ALL WEATHER

HOURS (L.S.T.): ALL

LOCATION: 34°55', 117°54', 2316'

HEIGHT ABOVE GROUND: 13'

SPEED (KNTS) DIR.	1-3	4-6	7-10	11-16	17-21	22-27	28-33	34-40	41-47	48-55	≥56	%	MEAN WIND SPEED
N	.8	.7	.2	.1	.0	.0						1.8	4.5
NNE	1.0	1.3	.4	.1	.0	.0						2.9	5.2
NE	.8	.9	.4	.2	.1	.0	.0					2.4	5.9
ENE	.5	.6	.5	.3	.0	.0	.0					2.0	6.8
E	.6	.8	.5	.3	.1	.0						2.3	6.6
ESE	.4	.4	.1	.0	.0	.0						.9	4.6
SE	.3	.3	.1	.0	.0	.0						.7	4.5
SSE	.3	.3	.1	.0	.0	.0						.6	4.3
S	.8	1.0	.4	.1	.0	.0						2.2	4.7
SSW	1.0	2.7	2.0	.4	.1	.0	.0					6.3	6.5
SW	1.4	4.3	5.3	3.7	1.4	.3	.0	.0				16.6	9.3
WSW	1.2	2.8	4.6	6.2	2.2	.4	.0					17.3	11.0
W	1.5	2.4	3.1	4.3	1.5	.4	.0	.0				13.3	10.5
WNW	1.3	1.8	1.0	1.8	1.1	.4	.1	.0				7.5	10.5
NW	.9	.9	.4	.5	.3	.1	.0					3.0	7.7
NNW	.4	.3	.1	.1	.0		.0					.9	5.0
CALM												19.3	
19.3	13.1	21.5	19.2	18.2	6.8	1.7	.2	.0				100.0	7.2

DATA FROM NATIONAL CLIMATIC CENTER
FEDERAL BUILDING – ASHEVILLE, N.C., 28801

TOTAL NUMBER OF OBSERVATIONS 86311

SURFACE WINDS

PERCENTAGE FREQUENCY OF WIND
DIRECTION AND SPEED
(FROM HOURLY OBSERVATIONS)

STATION	STATION NAME	YEARS	MONTH
23199	EL CENTRO CALIFORNIA NAAS	45-60	ALL

CLASS: ALL WEATHER

HOURS (L.S.T.): ALL

LOCATION: 32°49', 115°40', -43'

HEIGHT ABOVE GROUND:

SPEED (KNTS) DIR.	1-3	4-6	7-10	11-16	17-21	22-27	28-33	34-40	41-47	48-55	≥56	%	MEAN WIND SPEED
N	1.0	1.4	1.0	.6	.3	.1	.0	.0				4.5	7.8
NNE	.6	.8	.5	.2	.1	.0	.0					2.3	6.6
NE	.9	1.2	.6	.1	.0	.0	.0					2.9	5.2
ENE	.5	.8	.4	.1	.0	.0						1.8	5.2
E	1.1	1.8	1.0	.1	.0	.0	.0					4.1	5.3
ESE	.7	1.4	1.2	.4	.0	.0						3.7	6.4
SE	1.5	2.9	2.7	.8	.1	.0	.0					8.1	6.6
SSE	.8	1.6	1.5	.4	.0	.0	.0					4.4	6.5
S	1.3	2.0	1.2	.2	.0	.0	.0					4.8	5.4
SSW	.8	1.1	.5	.1	.0	.0						2.5	5.2
SW	1.5	2.1	1.2	.5	.3	.1	.0	.0				5.9	7.0
WSW	1.0	2.1	2.5	2.7	2.1	1.2	.3	.0	.0			11.9	12.6
W	2.1	4.7	5.8	3.6	2.1	1.0	.2	.0	.0			19.6	10.1
WNW	1.1	2.7	3.0	1.2	.4	.1	.0	.0				8.6	8.0
NW	1.4	2.3	1.7	.5	.1	.0	.0	.0	.0	.0		6.1	6.3
NNW	.6	1.0	.8	.5	.2	.1	.0					3.2	7.8
VARBL													
CALM												5.7	
5.7	17.1	30.0	25.7	12.2	5.7	2.8	.6	.1	.0	.0		100.0	7.6

DATA FROM NATIONAL CLIMATIC CENTER
FEDERAL BUILDING – ASHEVILLE, N.C., 28801

TOTAL NUMBER OF OBSERVATIONS 121517

SURFACE WINDS

PERCENTAGE FREQUENCY OF WIND
DIRECTION AND SPEED
(FROM HOURLY OBSERVATIONS)

STATION	STATION NAME	YEARS	MONTH
23131	GEORGE AFB CALIF/VICTORVILLE	42-46,48,50-72	ALL

CLASS: ALL WEATHER

HOURS (L.S.T.): ALL

LOCATION: 34°35', 117°23', 2849'

HEIGHT ABOVE GROUND: 13'

SPEED (KNTS) DIR.	1-3	4-6	7-10	11-16	17-21	22-27	28-33	34-40	41-47	48-55	≥56	%	MEAN WIND SPEED
N	.8	1.4	1.0	.3	.0	.0	.0	.0	.0			3.5	6.3
NNE	.5	1.1	1.0	.4	.1	.0	.0	.0				3.0	7.2
NE	.5	.7	.7	.4	.0	.0						2.2	7.3
ENE	.2	.4	.3	.1	.0	.0		.0				1.0	6.8
E	.4	.7	.6	.2	.0	.0	.0	.0				1.9	6.6
ESE	.4	1.0	1.1	.1	.0	.0	.0					2.7	6.4
SE	1.3	3.9	3.4	.3	.1	.0	.0	.0	.0			9.0	6.4
SSE	1.3	4.0	2.3	1.0	.5	.2	.0	.0	.0			9.3	7.6
S	2.1	5.2	3.5	3.1	1.5	.5	.0	.0	.0			16.0	9.0
SSW	1.3	2.9	2.6	2.0	.5	.1	.0	.0				9.3	8.4
SW	1.3	2.6	2.5	1.0	.2	.1	.0	.0	.0			7.6	7.3
WSW	.7	1.5	1.8	1.1	.5	.2	.1	.0				5.9	9.3
W	.9	1.8	2.8	2.9	1.4	.5	.1	.0				10.5	11.3
WNW	.4	.8	1.0	1.0	.5	.2	.0	.0	.0			3.9	10.5
NW	.5	.7	.5	.2	.1	.0	.0	.0				2.1	6.9
NNW	.4	.6	.4	.1	.0	.0	.0					1.6	6.1
CALM												10.4	
10.4	12.9	29.1	25.5	14.3	5.5	1.9	.3	.0	.0			100.0	7.4

DATA FROM NATIONAL CLIMATIC CENTER
FEDERAL BUILDING – ASHEVILLE, N.C., 28801

TOTAL NUMBER OF OBSERVATIONS 232810

SURFACE WINDS

PERCENTAGE FREQUENCY OF WIND
DIRECTION AND SPEED
(FROM HOURLY OBSERVATIONS)

STATION: ________ STATION NAME: Indio, CA (Coachella CAA) YEARS: Jan 1937 thru Aug 1940 MONTH: ALL

CLASS: ALL WEATHER HOURS (L.S.T.): ALL

LOCATION: 33°41', 116°10',-62'

HEIGHT ABOVE GROUND: ________

SPEED MPH / DIR.	4-15	16-31	32-47	>47								%	MEAN WIND SPEED
N	6.4	0.5	0.0									6.9	
NNE	0.5	0.1	0.0									0.6	
NE	1.1	0.0										1.1	
ENE	0.2	0.0										0.2	
E	0.9	0.0										1.0	
ESE	1.1	0.0										1.1	
SE	5.7	0.1										5.8	
SSE	3.3	0.1										3.3	
S	3.7	0.0										3.7	
SSW	1.4	0.0										1.4	
SW	2.6	0.0										2.6	
WSW	0.8	0.1										0.9	
W	4.5	0.1										4.6	
WNW	4.9	0.2										5.1	
NW	26.8	5.1	0.0									31.9	
NNW	5.4	3.1	0.0									8.5	
CALM												21.1	
21.1	69.3	9.4	0.1									100.0	

DATA FROM NATIONAL CLIMATIC CENTER
FEDERAL BUILDING – ASHEVILLE, N.C., 28801

TOTAL NUMBER OF OBSERVATIONS 27,948

SURFACE WINDS

PERCENTAGE FREQUENCY OF WIND
DIRECTION AND SPEED
(FROM HOURLY OBSERVATIONS)

LAN 090W — STATION

Lancaster — STATION NAME

1957 - 1964 — YEARS

ALL — MONTH

ALL — HOURS (L.S.T.)

ALL WEATHER — CLASS

34°35', 118°08', 2660', 2500 W. Avenue 1 — LOCATION

90' — HEIGHT ABOVE GROUND

SPEED MPH / DIR.												%	MEAN WIND SPEED
N												1.9	4.2
NNE												2.4	4.1
NE												5.1	4.5
ENE												5.2	5.0
E												4.7	3.6
ESE												2.7	2.8
SE												3.0	2.2
SSE												2.9	2.1
S												1.6	2.8
SSW												3.6	4.2
SW												11.8	10.5
WSW												19.9	11.0
W												19.3	11.0
WNW												10.0	11.6
NW												3.8	6.8
NNW												1.9	4.0
CALM													
												99.8	8.3

TOTAL NUMBER OF OBSERVATIONS 55,943

Data from South Coast Air Quality Management District
9420 Telstar Avenue
El Monte, CA 91731

Note: These data are available on an hourly basis.

SURFACE WINDS

PERCENTAGE FREQUENCY OF WIND DIRECTION AND SPEED (FROM HOURLY OBSERVATIONS)

STATION:

STATION NAME: Mojave, CA

YEARS: April 1945 thru September 1958

MONTH: ALL

CLASS: ALL WEATHER

HOURS (L.S.T.): ALL

LOCATION: 35°03', 118°11', 2,764'

HEIGHT ABOVE GROUND:

SPEED MPH / DIR.	3-7	8-12	13-20	21-30	31-40	> 40						%	MEAN WIND SPEED
N	2.8	0.7	0.1	0.0								3.6	
NNE	0.8	0.3	0.1	0.0								1.2	
NE	2.4	1.5	0.6	0.1	0.0							4.7	
ENE	1.3	0.8	0.2	0.0	0.0							2.4	
E	2.6	0.8	0.2	0.0								3.6	
ESE	0.5	0.1	0.0									0.6	
SE	1.1	0.1	0.0									1.3	
SSE	0.4	0.1	0.0									0.6	
S	1.1	0.5	0.2	0.0								1.8	
SSW	0.7	1.1	0.9	0.1	0.0							2.8	
SW	1.9	3.5	2.6	0.2		0.0						8.2	
WSW	1.1	1.8	1.3	0.2	0.0							4.3	
W	1.9	3.5	3.7	1.4	0.2	0.0						10.8	
WNW	1.0	3.5	7.6	3.6	0.4	0.1						16.3	
NW	2.4	2.9	5.9	1.9	0.2	0.0						13.3	
NNW	1.0	0.9	0.9	0.2	0.0							3.1	
CALM												21.6	
21.6	23.0	22.2	24.5	7.8	1.0	0.1							

DATA FROM NATIONAL CLIMATIC CENTER
FEDERAL BUILDING – ASHEVILLE, N.C., 28801

TOTAL NUMBER OF OBSERVATIONS 32,291

SURFACE WINDS

PERCENTAGE FREQUENCY OF WIND
DIRECTION AND SPEED
(FROM HOURLY OBSERVATIONS)

23179 (STATION) — Needles, CA (STATION NAME) — 1969 thru 1974 (YEARS) — ALL (MONTH)

ALL WEATHER (CLASS) — ALL (HOURS (L.S.T.))

34°46', 114°37', 919' (LOCATION)

HEIGHT ABOVE GROUND

SPEED Knots DIR.	1-3	4-6	7-10	11-16	17-21	> 21						%	MEAN WIND SPEED
N	0.1	1.6	2.4	2.8	1.9	1.0						9.8	13.2
NNE	0.0	1.0	0.7	0.3	0.1	0.0						2.2	8.2
NE	0.0	0.8	0.4	0.1	0.0	0.0						1.4	6.5
ENE	0.0	1.0	0.7	0.1	0.0	0.0						1.9	6.8
E	0.0	1.5	1.1	0.2	0.0	0.0						2.8	7.2
ESE	0.0	0.6	0.6	0.1	0.0	0.0						1.4	7.5
SE	0.0	0.6	0.6	0.3	0.0	0.0						1.6	8.4
SSE	0.0	0.8	1.2	1.0	0.2	0.0						3.3	10.1
S	0.1	1.8	4.2	3.5	0.8	0.4						10.6	10.6
SSW	0.0	1.8	3.4	1.6	0.3	0.0						7.3	9.2
SW	0.1	2.0	3.9	1.3	0.2	0.0						7.4	8.6
WSW	0.1	3.2	4.1	1.2	0.2	0.1						8.8	8.2
W	0.1	3.1	2.7	0.7	0.3	0.1						7.0	8.0
WNW	0.0	1.7	1.7	0.3	0.1	0.0						3.8	7.6
NW	0.0	1.2	1.8	0.5	0.1	0.0						3.8	8.5
NNW	0.0	1.1	2.2	1.8	0.6	0.2						6.0	11.0
Avg.	2.9	5.2	8.5	13.3	18.8	25.0							
CALM												21.0	7.4
21.0	0.7	24.0	31.7	15.9	4.9	1.7						100.0	

DATA FROM NATIONAL CLIMATIC CENTER
FEDERAL BUILDING – ASHEVILLE, N.C., 28801

TOTAL NUMBER OF OBSERVATIONS 43,794

SURFACE WINDS

PERCENTAGE FREQUENCY OF WIND
DIRECTION AND SPEED
(FROM HOURLY OBSERVATIONS)

23112 — STATION | NELLIS AFB NEVADA/LAS VEGAS — STATION NAME | 42-44,49-72 — YEARS | ALL — MONTH

ALL WEATHER — CLASS | ALL — HOURS (L.S.T.)

36°15', 115°02', 1880' — LOCATION

13' — HEIGHT ABOVE GROUND

SPEED (KNTS) DIR.	1-3	4-6	7-10	11-16	17-21	22-27	28-33	34-40	41-47	48-55	≥56	%	MEAN WIND SPEED
N	1.0	1.3	.7	.5	.2	.1	.0	.0				3.8	7.0
NNE	1.0	1.3	.8	.9	.5	.2	.0	.0	.0	.0		4.7	8.9
NE	1.8	2.7	2.4	1.6	.4	.1	.0	.0	.0	.0		8.8	7.7
ENE	.9	1.4	1.4	.5	.1	.0	.0	.0				4.3	6.8
E	1.4	1.9	1.6	.4	.1	.0	.0					5.3	6.2
ESE	.6	.8	.7	.3	.1	.0	.0	.0				2.6	6.7
SE	.8	1.1	1.0	.6	.2	.0	.0	.0	.0			3.7	7.6
SSE	.4	.6	.7	.8	.3	.1	.0	.0	.0			2.9	10.1
S	1.3	2.3	2.9	2.8	1.0	.3	.0	.0				10.7	9.8
SSW	1.1	1.5	1.4	1.6	.8	.4	.0	.0	.0			6.7	10.1
SW	1.2	1.6	1.2	1.2	.5	.2	.0	.0	.0			5.9	8.8
WSW	.5	.5	.3	.3	.1	.0	.0	.0				1.7	7.1
W	.9	.9	.4	.3	.1	.1	.0	.0	.0			2.7	6.7
WNW	.6	.5	.3	.3	.2	.1	.0	.0				2.1	9.0
NW	.8	.8	.4	.4	.2	.1	.0	.0				2.7	7.5
NNW	.4	.4	.2	.1	.0	.0	.0	.0				1.2	6.1
CALM												30.1	
30.1	14.8	19.5	16.3	12.7	4.7	1.6	.2	.0	.0	.0		100.0	5.8

DATA FROM NATIONAL CLIMATIC CENTER
FEDERAL BUILDING – ASHEVILLE, N.C., 28801

TOTAL NUMBER OF OBSERVATIONS 230638

SURFACE WINDS

PERCENTAGE FREQUENCY OF WIND
DIRECTION AND SPEED
(FROM HOURLY OBSERVATIONS)

23182 (STATION) — PALMDALE APT CALIF (STATION NAME) — 48-54,61-64,71-73 (YEARS) — ALL (MONTH)

ALL WEATHER (CLASS) — ALL (HOURS (L.S.T.))

34°38', 118°05', 2520' (LOCATION)

28' (HEIGHT ABOVE GROUND)

SPEED (KNTS) DIR.	1-3	4-6	7-10	11-16	17-21	22-27	28-33	34-40	41-47	48-55	≥56	%	MEAN WIND SPEED
N	.9	1.7	1.0	.2	.0	.0						3.8	5.7
NNE	.4	1.0	.7	.2	.0	.0	.0	.0				2.4	6.8
NE	.5	.9	.7	.3	.1	.0	.0					2.5	7.1
ENE	.2	.5	.6	.4	.1	.0		.0				1.9	8.7
E	.3	.6	.5	.3	.1	.0						1.9	7.7
ESE	.2	.5	.4	.1	.0	.0	.0					1.2	6.9
SE	.4	.9	.3	.1	.0	.0						1.7	5.3
SSE	.4	1.1	.5	.0	.0	.0	.0					2.1	5.6
S	1.3	5.1	3.3	.5	.1	.0	.0	.0				10.3	6.4
SSW	.8	3.7	3.2	2.0	1.1	.4	.0	.0				11.3	9.5
SW	1.3	3.4	4.5	5.8	3.1	1.2	.1	.0				19.5	11.7
WSW	.4	1.2	2.5	4.1	1.9	.4	.0	.0				10.6	12.4
W	.5	1.0	1.7	2.1	.9	.4	.1	.0		.0		6.7	11.6
WNW	.4	1.1	1.4	2.0	1.5	1.0	.2	.0				7.4	13.7
NW	.6	1.3	1.0	.7	.4	.2	.0	.0				4.3	9.3
NNW	.5	1.1	.6	.1	.0	.0	.0					2.4	6.3
CALM												10.0	
10.0	9.1	25.2	23.1	19.0	9.4	3.8	.4	.0		.0		100.0	8.8

DATA FROM NATIONAL CLIMATIC CENTER
FEDERAL BUILDING – ASHEVILLE, N.C., 28801

TOTAL NUMBER OF OBSERVATIONS 109166

SURFACE WINDS

PERCENTAGE FREQUENCY OF WIND DIRECTION AND SPEED (FROM HOURLY OBSERVATIONS)

STATION: ________ STATION NAME: Palm Springs AAF YEARS: May 1943 thru February 1946 MONTH: ALL

CLASS: ALL WEATHER HOURS (L.S.T.): ALL

LOCATION: 33°54', 116°33', 420'

HEIGHT ABOVE GROUND: ________

SPEED MPH / DIR.	1-3	4-12	13-24	25-31	32-46	≥47	%	MEAN WIND SPEED
N	0.5	3.4	0.6	0.2			4.7	8.9
NNE	0.0	0.9	0.2	0.1			1.2	10.0
NE	0.3	1.7	0.1				2.2	6.4
ENE	0.1	0.9	0.1				1.0	6.8
E	0.9	6.2	0.4				7.5	6.9
ESE	0.1	4.0	0.3				4.5	7.6
SE	0.9	6.3	0.2				7.5	6.2
SSE	0.2	1.6	0.1				1.8	5.9
S	0.7	2.3	0.1				3.0	5.1
SSW	0.2	1.3	0.1				1.6	6.3
SW	0.6	3.7	0.1				4.4	5.8
WSW	0.2	2.4					2.6	6.2
W	0.7	5.0	0.1				5.9	5.8
WNW	0.2	3.1	0.4				3.7	8.1
NW	1.7	13.9	9.6	1.6	0.2		27.0	12.3
NNW	0.2	5.5	1.7	0.2	0.1		7.7	10.5
CALM							13.9	7.6
13.9	7.6	62.2	14.1	2.1	0.3		100.0	

DATA FROM NATIONAL CLIMATIC CENTER
FEDERAL BUILDING – ASHEVILLE, N.C., 28801

TOTAL NUMBER OF OBSERVATIONS 24,286

SURFACE WINDS

PERCENTAGE FREQUENCY OF WIND
DIRECTION AND SPEED
(FROM HOURLY OBSERVATIONS)

STATION: ______ STATION NAME: Rice, CA AAF YEARS: June 1943 thru March 1944 MONTH: ALL

CLASS: ALL WEATHER HOURS (L.S.T.): ALL

LOCATION: 34° 04', 114° 50', 882'

HEIGHT ABOVE GROUND: ______

SPEED MPH / DIR.	1-3	4-12	13-24	25-31	32-46	≥ 47						%	MEAN WIND SPEED
N	0.5	2.3	0.6	0.1	0.0							3.6	9.0
NNE	0.1	0.9	0.3	0.1								1.4	10.1
NE	1.0	6.6	1.5	0.0								9.1	8.2
ENE	0.2	1.6	0.3									2.1	7.6
E	1.2	6.5	0.3	0.1									5.9
ESE	0.4	1.6	0.4										7.8
SE	0.7	6.2	0.5										6.9
SSE	0.1	1.7	0.7										10.0
S	0.8	5.0	0.9	0.0									7.8
SSW	0.2	1.6	0.4										8.3
SW	0.7	5.0	0.6	0.1									7.3
WSW	0.1	1.9	0.1	0.1									7.4
W	1.1	10.8	1.0	0.0									7.4
WNW	0.4	6.4	1.2										9.1
NW	0.9	16.3	5.4	0.2	0.0								10.1
NNW	0.1	1.0	0.6	0.1									11.8
CALM												0.2	8.3
0.2	8.5	75.6	14.9	0.8	0.0							100.0	

DATA FROM NATIONAL CLIMATIC CENTER
FEDERAL BUILDING – ASHEVILLE, N.C., 28801

TOTAL NUMBER OF OBSERVATIONS ______

SURFACE WINDS

PERCENTAGE FREQUENCY OF WIND DIRECTION AND SPEED (FROM HOURLY OBSERVATIONS)

STATION: ______ STATION NAME: Sandberg YEARS: January 1932 thru December 1938 MONTH: ALL

CLASS: ALL WEATHER HOURS (L.S.T.): ALL

LOCATION: 34°45', 118°44', 4,524'

HEIGHT ABOVE GROUND: 30'

SPEED MPH / DIR.	4-15	16-31	32-47	> 47							%	MEAN WIND SPEED
N	5.8	4.1	0.2	0.0							10.2	
NNE	1.4	0.5	0.0								2.0	
NE	5.1	7.0	0.7	0.0							12.7	
ENE	1.1	2.6	0.3	0.0							4.1	
E	0.8	1.3	0.3	0.0							2.4	
ESE	0.4	0.2	0.0								0.6	
SE	0.8	0.2									1.0	
SSE	2.0	1.4	0.0								3.4	
S	8.2	4.7	0.1	0.0							13.0	
SSW	4.2	1.9	0.1								6.2	
SW	5.4	0.4	0.0								5.9	
WSW	0.8	0.0	0.0								0.8	
W	2.3	0.1									2.4	
WNW	1.1	0.5	0.0								1.7	
NW	9.0	11.4	1.1	0.1							21.5	
NNW	3.6	6.8	0.5	0.0							10.9	
CALM											1.2	15.3*
1.2	52.0	43.3	3.3	0.2							100.0	

DATA FROM NATIONAL CLIMATIC CENTER
FEDERAL BUILDING – ASHEVILLE, N.C., 28801

TOTAL NUMBER OF OBSERVATIONS 59,682

*From local climatological data.

SURFACE WINDS

PERCENTAGE FREQUENCY OF WIND
DIRECTION AND SPEED
(FROM HOURLY OBSERVATIONS)

STATION:

STATION NAME: Silver Lake, CA (CAA)

YEARS: August 1940 thru July 1941

MONTH: ALL

HOURS (L.S.T.): ALL

CLASS: ALL WEATHER

LOCATION: 35°20', 116°06', 925'

HEIGHT ABOVE GROUND:

SPEED MPH / DIR.	4-15	16-31	32-47	> 47								%	MEAN WIND SPEED
N	3.2	0.8	0.0									4.1	
NNE	0.7	0.7	0.0									1.5	
NE	1.9	0.0										1.9	
ENE	0.3	0.0										0.3	
E	4.2	0.0										4.2	
ESE	2.7	0.1										2.8	
SE	17.8	0.3										18.1	
SSE	6.2	0.4										6.6	
S	10.2	0.7	0.0									10.9	
SSW	3.2	0.4										3.6	
SW	3.9	0.5										4.4	
WSW	1.4	0.7										2.1	
W	1.9	1.5	0.1	0.0								3.5	
WNW	1.7	0.8	0.1									2.5	
NW	5.0	0.4										5.3	
NNW	2.8	1.0	0.0									3.8	
CALM												24.3	
24.3	67.1	8.3	0.2	0.0								100.0	

DATA FROM NATIONAL CLIMATIC CENTER
FEDERAL BUILDING – ASHEVILLE, N.C., 28801

TOTAL NUMBER OF OBSERVATIONS 8,732

SURFACE WINDS

PERCENTAGE FREQUENCY OF WIND
DIRECTION AND SPEED
(FROM HOURLY OBSERVATIONS)

STATION: ______ STATION NAME: Thermal FAA YEARS: Jan 1957 thru Dec 1961 MONTH: ALL

CLASS: ALL WEATHER HOURS (L.S.T.): ALL

LOCATION: 33°38', 116° 10', -115'

HEIGHT ABOVE GROUND: ______

SPEED (KNTS) DIR.	1-3	4-15	16-25	/7-25								%	MEAN WIND SPEED
N	0.1	13.0	0.5	0.0								13.6	
NNE	0.0	2.0	0.0									2.1	
NE	0.0	1.1	0.0									1.1	
ENE	0.0	0.3	0.0									0.3	
E	0.0	0.4	0.0									0.4	
ESE	0.0	0.8	0.0									0.9	
SE	0.1	6.7	0.4	0.0								7.2	
SSE	0.0	9.1	0.7	0.0								9.9	
S	0.1	5.7	0.1									5.8	
SSW	0.0	1.0	0.0									1.1	
SW	0.1	1.2	0.0									1.3	
WSW	0.0	0.8	0.0	0.0								0.8	
W	0.1	1.4	0.1									1.5	
WNW	0.1	2.5	0.2	0.0								2.8	
NW	0.1	12.4	1.2	0.0								13.7	
NNW	0.1	21.3	4.3	0.1								25.7	
CALM												11.8	
11.8	1.0	79.5	7.6	0.1								100.0	

DATA FROM NATIONAL CLIMATIC CENTER
FEDERAL BUILDING – ASHEVILLE, N.C., 28801

TOTAL NUMBER OF OBSERVATIONS 43,823

SURFACE WINDS

PERCENTAGE FREQUENCY OF WIND
DIRECTION AND SPEED
(FROM HOURLY OBSERVATIONS)

STATION: Twenty Nine Palms,CA Condor (STATION NAME)

YEARS: July 1942 thru March 1943

MONTH: ALL

CLASS: ALL WEATHER

HOURS (L.S.T.): ALL

LOCATION: 34° 08', 116° 02', 1,778'

HEIGHT ABOVE GROUND:

SPEED MPH / DIR.	1-3	4-12	13-24	25-31	32-46	≥ 47						%	MEAN WIND SPEED
N	2.2	3.7	0.3	0.0	0.0							6.1	5.5
NNE	0.2	0.3	0.0									0.5	5.3
NE	0.5	0.9	0.0									1.4	5.1
ENE	0.1	0.4	0.0									0.5	7.0
E	0.7	3.4	0.5	0.0								4.7	7.5
ESE	0.4	1.5	0.1									2.0	5.6
SE	1.2	2.8	0.3	0.0								4.4	6.2
SSE	0.3	0.2	0.1									0.5	5.6
S	0.7	1.4	0.2									2.4	6.2
SSW	0.3	0.4	0.3		0.0							1.1	8.9
SW	1.1	2.3	1.0	0.2	0.0							4.6	9.3
WSW	0.6	1.5	0.7	0.0	0.0							2.9	9.4
W	2.6	6.6	1.5	0.1	0.0							10.8	7.5
WNW	1.7	5.4	1.1	0.3	0.1	0.1						8.7	8.9
NW	5.7	24.0	2.3	0.3	0.1							32.3	6.9
NNW	1.2	4.6	0.3	0.0								6.2	6.2
CALM												10.9	6.4
10.9	19.6	59.4	8.7	1.0	0.3	0.1						100.0	

DATA FROM NATIONAL CLIMATIC CENTER
FEDERAL BUILDING – ASHEVILLE, N.C., 28801

TOTAL NUMBER OF OBSERVATIONS 6,567

SURFACE WINDS

PERCENTAGE FREQUENCY OF WIND
DIRECTION AND SPEED
(FROM HOURLY OBSERVATIONS)

23195 (STATION) — YUMA ARIZONA IAP (STATION NAME) — 48-71 (YEARS) — ALL (MONTH)

ALL WEATHER (CLASS) — ALL (HOURS (L.S.T.))

32°40', 114°36', 20' (LOCATION)

20' (HEIGHT ABOVE GROUND)

SPEED (KNTS) DIR.	1 - 3	4 - 6	7 - 10	11 - 16	17 - 21	22 - 27	28 - 33	34 - 40	41 - 47	48 - 55	≥56	%	MEAN WIND SPEED
N	1.0	3.4	3.1	1.8	.4	.1	.0					9.7	8.0
NNE	1.0	3.4	2.6	.7	.1	.0	.0					7.7	6.6
NE	.8	2.1	1.1	.2	.0	.0	.0					4.3	5.8
ENE	.5	1.1	.4	.1	.0	.0						2.2	5.7
E	.7	1.0	.3	.1	.0	.0	.0					2.2	5.3
ESE	.4	.8	.4	.1	.0	.0						1.7	5.8
SE	.6	1.4	1.9	1.6	.3	.0	.0					5.8	8.9
SSE	.5	1.9	3.0	2.6	.4	.0	.0					8.5	9.5
S	.8	2.6	3.2	1.6	.1	.0						8.4	7.8
SSW	.6	1.7	1.8	.7	.0	.0	.0					4.9	7.1
SW	.8	2.6	1.9	.3	.0	.0						5.6	6.2
WSW	.6	2.6	2.1	.4	.0	.0						5.7	6.5
W	.7	3.0	2.5	.9	.2	.1	.0					7.3	7.5
WNW	.6	2.5	2.2	1.3	.3	.1	.0	.0	.0			6.9	8.2
NW	.6	1.8	1.3	.5	.1	.0	.0					4.3	6.9
NNW	.6	1.7	1.8	.9	.1	.0	.0					5.1	7.8
CALM												9.6	
9.6	10.8	33.8	29.6	13.8	2.1	.3	.0	.0	.0			100.0	6.7

DATA FROM NATIONAL CLIMATIC CENTER
FEDERAL BUILDING – ASHEVILLE, N.C., 28801

TOTAL NUMBER OF OBSERVATIONS 160705

A76989—850 1-78 3M

Appendix D

Water Need is an index of relative water need which directly relates to potential evapotranspiration . It is predominately a function of mean annual temperature but rises slightly as the mean annual temperature range increases.

Warmth is the warmth of climate defined as the mean temperature at the onset and exit of the summer period.

Days Warmth represent the duration of the summer period and expressed as the number of days greater than the warmth value.

Temperateness is an index of climatic temperateness which approaches 100 as the annual range of temperature approaches 0 and the mean annual temperature approaches 57.2°F (14°C).

Per Cent of Annual Hours Freezing represents the frequency of annual hours with temperature less than freezing and is expressed as a percentage of all hours in a year.

Mean Annual Range of Temperature is expressed in degrees Centigrade or Farenheit and represents the difference between the mean monthly temperature of the warmest month and the mean monthly temperature of the coldest month.

Mean Annual Temperature is calculated by taking the average of the sum of all 12 mean monthly temperatures.

SELECTED BIBLIOGRAPHY

American Association for the Advancement of Science (1963). Aridity and Man. Washington: AAAS.

Angell, J. K., et al. (1961), "Estimation of Vertical Air Motions in Desert Terrain From Tetroon Flights," Monthly Weather Review, 89 (August), 273-283.

Bailey, Harry P. (1960), "A Method of Determining the Warmth and Temperateness of Climate," Geografiska Annaler, 42, 1-16.

_______________ (1966), "The Mean Annual Range and Standard Deviation as Measures of Dispersion of Temperature Around the Annual Mean," Geografiska Annaler, 48, 183-194.

_______________ (1964), "Toward a Unified Concept of the Temperate Climate," Geographical Review, 54, 516-545.

Battan, Lewis J. (1969), "Hail on a Mountain in Arizona," Journal of Applied Meteorology, 8 (August), 592-595.

Berkosfsky, L. (1976), "The Effect of Variable Surface Albedo on the Atmospheric Circulation," Journal of Applied Meteorology, 15 (November), 1139-1144.

California, Department of Water Resources (1971). Climatological Stations in California 1971, Bulletin No. 165.

_______________ (1977). Hydrologic Data, Vol. 5 (Southern California).

_______________ (1975). Summary of Short-Duration Precipitation Frequency in Riverside County.

_______________ (1978). Wind in California, Bulletin No. 185.

California, Division of Mines (1954), "Climate, Vegetation, and Land Use in Southern California," Harry P. Bailey, in Geology of Southern California, Bulletin 170.

Douglas, Charles, University of Nevada, Las Vegas, personal communication.

Felton, Ernest (1965). California's Many Climates, Palo Alto, CA: Pacific Books.

Hales, John E. Jr. (1974), "Southwestern United States Summer Monsoon Source - Gulf of Mexico or Pacific Ocean," Journal of Applied Meteorology, 13 (April), 331-342.

Hart, Merriam C. (1893), "Notes on the Geographic and Vertical Distribution of Cactuses, Yuccas, and Agave, in the Deserts and Desert Ranges of Southern California, Southern Nevada, Northwestern Arizona, and Southwestern Utah," North American Fauna, 7, 345-359.

Huning, James R. and Robert Hicks (1974). Time Lapse Photography of Pollutant Advection into the California Desert, for NWC China Lake.

Huning, James R. and Charles F. Hutchinson (1974), "The Palo-Verde-Ironwood Association: An Outlier of the Sonoran Desert in Eastern California," paper presented at the Association of Pacific Coast Geographers, Fresno, CA.

Huning, James R. (1974), unpublished manuscript on precipitation trends in the California Desert.

Huning, James R. and Robert M. Petersen (1973). Use of Yucca brevifolia as a Surrogate for Detection of Near-Surface Moisture Retention. Technical Report N-73-1. Department of Geography, University of California, Riverside.

Hunolt, Gregory W. (1977), "VHRR Digital Tape User's Guide," National Climatic Center, Satellite Data Services Branch.

Ives, R. (1949), "Climate of the Sonoran Desert," Annals of the Association of American Geographers, 34, 143-187.

James, J. W. (1966), "A Modified Köppen Classification of California's Climates According to Recent Data," California Geographer, 7, 1-12.

Jorgensen, Donald L., "A Synoptic Climatology of Winter Precipitation From 700-mb Lows for Intermountain Areas of the West," Journal of Applied Meteorology, 6 (October), 782-790.

Jurwitz, L. R. (1953), "Arizona's Two-Season Rainfall Pattern," Weatherwise, 6, 96-99.

Kaimal, J. C. (1970), "Case Studies of a Convective Plume and a Dust Devil," Journal of Applied Meteorology, 9, (August) 612-620.

Kelso, Raymond, NWC China Lake, personal communication.

Kimball, M. H. and F. A. Brooks (1959), "Plant Climates of California," California Agriculture, (May), 7-12.

Klein, William H. (1968), "Relation Between Upper Air Flows and Winter Precipitation in the Western Plateau States," Monthly Weather Review, 96, 162-168.

Larson, James L. (n.d.). Tropical Storm. San Diego, CA: CALTRANS.

Legeckis, Richard and J. Pritchard (1976), "Algorithm for Correcting the VHRR Imagery for Geometric Distortions Due to Earth Curvature, Earth Rotation, and Spacecraft Roll Attitude Errors," NOAA Technical Memorandum NESS 77 (April).

Logan, Richard F. (1951), "Winter Temperatures of a Mid-Latitude Desert Mountain Range," Geographical Review, 51, 236-252.

Los Angeles, City of, Department of Water and Power, historical files.

McDonald, James E. (1956). Variability of Precipitation in an Arid Region: A Survey of Characteristics for Arizona. Technical Report No. 1 University of Arizona, Institute of Atmospheric Physics.

Mitchell, Van L. (1976), "The Regionalization of Climate in the Western United States," Journal of Applied Meteorology, 15, (September) 920-927.

Ouimette, James R. (1974). Survey and Evaluation of the Environmental Impact of Naval Weapons Center Activities, Department of Public Works, China Lake, CA: Naval Weapons Center (June).

Reitan, Elmar R. (1967), "The Prediction of Clear Air Turbulence Over Mountainous Terrain," Journal of Applied Meteorology, 6, (June) 549-556.

Sellers, William (1964), "Potential Evapotranspiration in Arid Regions," Journal of Applied Meteorology, 3, 98-104.

Sharp, Robert P. and Dwight L. Carey (1976), "Sliding Stones, Racetrack Playa, California," Bulletin, Geological Society of America, 87, 1704-1717.

United States, Department of Commerce (1964), Climatology of the United States No. 86-4, Decennial Census of United States Climate - Supplement for 1951-1960.

______________ (selected years). Climatological Data for California.

______________ . Monthly Normals of Temperature, Precipitation, and Heating Degree Days. U. S. Weather Bureau. Decennial Census of the United States Climate, Series 81, Period of Record, 1931-1960.

______________ (1975-1977, selected dates). National Oceanographic and Atmospheric Administration. Satellite Imagery, NOAA-4,5, SMS-2.

______________ (1975). Storm Data, 7 (No. 7 and 9).

______________ (selected dates). U. S. Daily Weather Maps.

United States, Department of the Interior, Geological Survey (selected dates). Landsat Imagery EROS Data Center.

______________ (selected dates). U-2 Imagery. EROS Data Center.

United States Department of the Interior, National Park Service, unpublished reports, Death Valley National Monument.

United States Naval Weapons Center (1977). Climatological Summaries for 1946 Through 1976. Meteorological Section (January).